(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY

BY

R. M. VAN ARSDALE

140 NASSAU STREET, NEW YORK

J. S. BONSALL, Business Manager.
F. H. THOMPSON, Eastern Representative

R. V. WRIGHT, E. A. AVERILL, } Editors.

APRIL, 1909

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While Mr. Pomeroy has never been a railway mechanical department employee he has, for many years, as a representative of manufacturing interests, come into intimate contact with the officials of that department. As assistant to the general manager of a large locomotive building plant he has had special opportunities for studying the design and manufacture of locomotives. As the steam railroad representative of one of the most important electrical companies, he has not only exploited the possibilities of the application of electricity to steam road conditions, but also in the designing and equipping of railroad shops; during this time he was connected in a consulting capacity on the engineering details of some of the largest railway shop plants in this country. Having had experience with the designing and equipping of many railroad shops, and having watched their operation closely, he has gained a much broader view of the situation than could possibly be enjoyed by one having a less extensive experience or having an intimate acquaintance with one or two plants only.

A most pains taking investigator with systematic and well considered methods of classifying and investigating facts, he has developed the faculty to a marked degree, if indeed he was not born with it, of eliminating the inessential details or less important facts, and getting to the very root of things. Having access to the data of many plants and being an indefatigable worker he has developed principles and solved problems which others could not have done. By those who know him intimately, and this includes many of the leaders in railroad mechanical department affairs, he is regarded as an authority on questions referring to railroad repair shop requirements and the possibilities of the substitution of electric for steam locomotives.

With a rare unselfishness his knowledge has at all times been at the service of his friends. So quietly and unobtrusively has he worked that his name has not even been connected with many of the most important developments for which he has been largely responsible. His work in connection with the Master Mechanics' Association has been exceedingly important, but it has been done in such a characteristically quiet way that but very few realize its extent or importance.

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In spite of the important work upon which he has been engaged he never misses an opportunity to encourage and help the

young men with whom he comes in contact and many young men owe their advancement, at least to some extent, to a quiet word or suggestion made to a superior officer, although the young men themselves may not know or realize to whom they are really indebted.

BELTING.

One of the most forceful arguments, showing the necessity of buying only high grade belting and of properly installing and looking after it, was the experience at the Topeka shops of the Atchison, Topeka & Santa Fe Railway, as described in the December, 1906, issue of this journal. In fourteen months the cost of maintaining the belting, including labor, supplies and new belting, was reduced from $1,000 to $310 per month. These figures have been still further reduced as the older belting has gradually been replaced by that bought under the new specifications, which call for belting of the best quality. The best practice indicates that the cost of maintaining belts should average yearly about 14 per cent. of its first cost.

What is the best qualiy of belting? The best belting is obtained from the native American steer when killed at about four years of age. Only a certain part of the hide is suitable for belting and the best quality is taken from a section about 30 in. wide, 15 in. each side of the backbone, and about 4 ft. long, measured from the tail. This should weigh about 16 ozs. to a square foot. A good second grade of belting may be secured from strips 6 in. wide taken at either side of the above section. The rest of the hide, consisting of the flanks and belly, is not suitable for belting but may be used to advantage for the making of halters, and other products.

As a matter of fact much of this inferior stock is made into belts, which, although sold at a lower price, proves very expensive to the user in the end. The hide or belting butt, as it is called, should not only be carefully selected but be tanned with oak bark and by slow process, and be properly curried, stretched and finished before it is cut into strips. That part of the butt directly over the backbone is of greater density and vitality and the fibres are more uniform than in the rest of the belting butt. Having greater strength and less elasticity this portion of the butt is especially valuable for the wider belts, but the center of the belt must correspond to the center of the butt, or that part directly over the backbone, in order to have the belt equally balanced so that it will run true.

How is it possible to check the grade of the belting? If the manufacturer has a regular system of cutting the strips it is possible, if the purchaser has a sample belting butt with the strips cut according to the same system, to check the belting with these strips. A movement is now on foot to have every large user furnished with the sides and centers of a butt showing the methods used in cutting the strips to get the various widths of belting. Such a system, while it checks the part of the butt from which the belt is taken, does not locate carelessness in the preparation of the leather. The only way in which the users of belts can protect themselves against this is to deal with reputable firms only and to insist that the maker's name and brand be marked on the belting at frequent intervals. The history should be kept of each belt installed in a shop, so that the user can know absolutely whether the belt is giving the service which he should have from it.

The railroads should buy belting on as definite and absolute specifications as other supplies. The great cost of replacements of belting in railroad shops is largely due to the fact that it is bought at the lowest price obtainable and too little atention is paid to the quality delivered.

GRINDING CAR AXLE JOURNALS.

It has been suggested that the railroads could add considerably to the life of the car axles by grinding the journals after they have become worn instead of turning them on a lathe. It is believed that the saving which could be made would, within a short time, pay for the cost of installing the necessary grinding machine. Under present conditions, when an axle is re-turned it is necessary in order to get the best results to have the cutting tool pass underneath the low spot on the journal. With a grinding machine it would be possible to true the journal absolutely without removing an ounce more material than necessary.

This idea of regrinding the journals has appealed to several officials to whom it has been submitted. The only objection which was brought up was that the fine particles from the grinding wheel might become imbedded in the surface of the journal and cause hot boxes. The fallacy of this objection can readily be seen when it is recalled that a large number of railroads have been grinding their piston rods for several years. The links and link blocks of the valve motion are also ground. Parts of an automobile, including the various journals and the crank shafts, are ground and no difficulty of this kind has ever been experienced. The following is from an article written by Charles H. Norton, who probably knows more about grinding and grinding machines than any other man in this country or abroad.

"Another erroneous impression, not, however, so common, is that emery adheres to ground surfaces, causing cutting of bearings when used. It would seem clear to reason that should the emery adhere to the steel, there could be no grinding, but instead the wheel would be torn away. The fact is that neither the microscope nor chemical laboratory reveals an atom of emery in any form adhering to the steel. This has been thoroughly demonstrated and yet there are mechanics with large enterprises in charge who will not grind machine parts because they are so sure that emery adheres to them.

"A good illustration of this point is furnished by the well-known air-brake mechanism. Some fourteen years ago the writer designed special machines for grinding the cylinders of the so-called "triple." This cylinder is about 3½ in. in diameter by 1¼ in. deep, having a bottom, and is brass lined; the brass piston working very freely, yet air tight, in this brass lining.

"The general belief at that time was that emery would remain on the brass surface and cause scratching, and it was with no little effort that the writer overcame this objection. When tests were made it was found that a blast of air removed all dust from the interior of the cylinder and ports and that the life of the cylinders was very much increased over the lathe-finished ones.

"There still remain a few who suppose that copper, babbitt, lead and soft rubber cannot be ground with emery and corundum wheels, because the material adheres to the cutting wheel; when, the fact is, there is no substance of which the writer has any knowledge that cannot be ground successfully with a wheel suitably constructed for each case."

At present the fillets at either end of the journal vary considerably for the different size standard M. C. B. axles. It would, of course, be better to have the fillets at the outer end of the journals, and also those at the inner end, standardized so as not to have to change the grinding wheels for different size journals. If it is desired to repair the journals with the wheels removed, and to grind the wheel fit as well as the journal, it will be necessary to make the fillets at the inner end of the journal and at both ends of the wheel fit the same size.

RAILROAD OUTLOOK IMPROVING.

Many signs point to a return of activity in the construction and extension of railroads, not only reasonably soon, but under such conditions that railroad projects will be undertaken with as much confidence and breadth of scope as other industrial and commercial enterprises.

So far as the tariff is concerned, it is not so much fear of what the schedules will be, as delay until it can be seen what they are, that causes hesitation. Never before in the history of the tariff has a bill enjoyed such a thorough going-over by the experts as the Payne Bill before its introduction into the House and it is understood that when the measure is sent to the Senate,

the Committee on Finance of that branch will have considered it step by step and offer it for debate at the earliest possible moment. Pressure will be strong on all sides for short speeches and experienced observers are predicting that the bill will be signed very much earlier in the year than has been the case after previous revisions.

Other conditions, such as agricultural prosperity and activity in the manufacture and distribution of dry-goods, are sound and improving. The special reason for hesitation which has beset the railroad managers and officers, namely, the fear of hostile legislation which would make extensive construction hazardous, is now rapidly giving way to a feeling that the American people are being touched in one of the strongest features of their nature—the desire to see fair play—and many concerns making material and equipment for railroads are contemplating the future in a very hopeful way, while many of them are planning extensions to their plants to be carried out as soon as business is somewhat better.

Considering these conditions, the Railway Business Association issues the following: "The spirit of fair play towards railroads is unmistakably gaining ground. Signs of its approach can be seen here, there and everywhere throughout the country. A splendid nucleus of influential citizens who earnestly advocate moderation has been developed ready to help us disseminate, in widening circles, the doctrine of good nature in the discussion of railroad restrictions. We believe the present opportunity to place sound views as to railroads before the public is unique.

"Influential newspapers north, south, east and west are boldly advocating conservatism. Where a few editors urge moderation editorially, many now open their news columns to matter setting forth the needs of the transportation interests. We are confident that if the friends of the railroads will now speak under a concerted plan their words will be adequately spread before the people.

"Great interests, through their commercial organizations and their trade press, are declaring for conservatism. These men are the shippers of the country. They are becoming convinced that improved transportation is to be had by study and conference rather than by assault. We hope to impress this view upon others who still hesitate or who at present decline to express like sentiment, and we feel that the degree of our success in this direction will depend largely upon the support our efforts receive.

"Congress adjourned on March 4 without enacting any further restrictions of consequence on railroads, yet the members can return to their homes without fear of having forfeited their neighbors' good will. Some State Legislatures appear to be nearing adjournment with a similar record and a like confidence in the forbearance of their constituents. Even in the most radical Legislatures there has been decided resistance to purely hostile proposals. It looks as if there would not be a 'bumper crop' this year for the agitator.

"At a time when the overturn by judicial process of a two-cent passenger rate is widely received as a matter of course, we cannot avoid the conviction that the transportation interests will be able to command fair consideration at the bar of public opinion.

"The appeal we have been making to business men and working men to regard, in their own interest, railroad prosperity as vital, has still many ears to reach and many minds to convert, but it has gone far; a large field has been tilled. It is now for us to sow seed in the soil thus prepared or to be prepared.

"The public is developing a readiness to hear arguments without prejudice. We do not desire that regulation shall cease, or expect that our particular views as to specific measures will invariably and everywhere prevail. We shall feel that a useful service has been performed if we can seize upon the present receptive mood of the public and lay before them certain general fundamental principles of railroad economics, concerning which there has been much loose thinking. Once a large number of shippers, workingmen and citizens in general have been led to give careful consideration to our view of these problems, ideas will lodge permanently in their minds which may affect legislation for many years to come.

"The iron is hot. Now is the time to strike.

"The great industrial interest which the Railway Business Association is endeavoring to represent has before it a splendid opportunity for effective work. We need the influence and the financial support of more members in order that we may do this work thoroughly. If you have not joined, we earnestly urge you to do so at once and add the force of your co-operation and your contribution to a movement which many careful observers believe can, if adequately supported, do very much to promote a healthy stability in the conditions of railroad management, upon which the permanent and expanding prosperity of your business so largely depends."

THE RAILROAD CLUBS.

Central Railroad Club (Buffalo, N. Y.)—The next meeting of the club will be held at the Hotel Iroquois on the evening of Friday, May 14.

Mr. John McE. Ames presented a paper on "The Use of Steel in Passenger Car Construction" at the March meeting, which considered briefly the primary reasons for the introduction of this material in passenger car construction and described the detailed features of a car, particularly as regards the use of other material than steel for interior finish and fittings. The best practice, in the author's estimation, was given for practically all of the different features. The matter of weight and cost was briefly considered; an important point in this connection was the greatly reduced liability for claims, when a wreck occurs, with steel equipment. This, in connection with the reduced cost of maintenance, more than offsets any increased price for equipment of this kind.

Secretary, H. D. Vought, 95 Liberty St., New York.

Canadian Railway Club (Montreal, Can.)—The meeting of April 6 will be given up to a paper on "Snow Fighting" by A. W. Wheatley, manager of the Montreal Locomotive Works. The discussion of the paper on "Shop Time Keeping," presented at the February meeting will be continued. The meeting of May 4 will be the annual meeting of the club; the subject of the paper has not yet been announced.

The paper on "Shop Time Keeping and Labor Distribution," by E. E. Lloyd, which was presented at the February meeting, drew attention to the importance of extreme accuracy and rapidity in shop time keeping. A number of the older systems were briefly mentioned and the weak points in each clearly pointed out. The modern methods of checking in and out men and distributing accounts were fully described and the important advantages of each mentioned. Samples of the blanks used by the foremen in distributing the accounts and the forms used in reporting the time, and other matters in connection with the shopmen, were illustrated.

This paper deals with a feature which in many cases is not given the attention that it really deserves.

Secretary, James Powell, P. O. Box 7, St. Lambert, Nr. Montreal, Can.

New England Railroad Club (Boston, Mass.)—At the regular meeting of the club to be held at the Copley Square Hotel, Boston, on April 13, Mr. George F. Baker will present a paper on "Smoke Prevention in Relation to Combustion." Dinner will be served at 6.30 P. M. and the business session of the club will start at 8 o'clock.

"The Single Phase Railway System" was the subject of a paper by N. W. Storer of the Westinghouse Electric & Mfg. Co., which was presented at the January meeting. The general subject of electric traction and the history of its application to steam railways up to the present time, as well as an elemenary discussion of the development of the electrical science, occupied the first part of the paper; following this was a comparison between direct current and single phase alternating current for use in heavy service, giving the advantages and disadvantages of each. Then followed quite an extensive description of the different designs of single phase equipment that have been installed in the last three or four years, showing the present state of the art. The discussion consisted largely of questions from the members.

Secretary, George H. Frazier, 10 Oliver St., Boston, Mass.

New York Railroad Club.—At the meeting of March 19 the subject of "The Abuse of the M. C. B. Repair Card" was briefly discussed by Messrs. Chamberlain and Goodnough. Following this the electrical subjects were taken up. Mr. McClellan, in a very broad and conservative manner, considered the future of the electrification of steam railways and in that connection advised very strongly the adoption of standards for many features in electrification as soon as possible. Among these was the location of the third rail, of the over-head trolley, voltage, frequencies, etc. W. S. Murray gave some of the later experiences of the New Haven Railroad with electric traction and stated among other things, he was convinced that in a similar work of this kind it would be better to have the power house generate at a lower voltage, which could be stepped up by transformers at the power house. Mr. Murray stated that the mileage of the New Haven electric locomotives averaged 210 miles per day. Mr. Kattee, of the New York Central, gave some very interesting figures in connection with the train movement at the Grand Central Station and of the electric service on the N. Y. C. The N. Y. C. electric trains have during the past year averaged 3,000 miles per minute of delay. There are 450 electric train movements in and out of the Grand Central every 24 hours, which require 120,000 K. W. hours of current. C. L. de Muralt spoke to the effect that he believed standardization of details would be very foolish at the present time, stating that all important details were already practically standardized. He discussed the three phase current for use on railways, speaking very strongly in favor of it. The three phase system gives a great reduction in the weight of a locomotive, a constant speed irrespective of the resistance, a completely enclosed motor and the disadvantage of two overhead wires are offset by the absence of a commutator. Messrs. Storer and Stott also presented discussions. An extensive discussion by L. C. Fritch, of the Illinois Central, will be printed in the Proceedings.

The meeting of April 16 will be on the subject of "Air Brakes."

Secretary, H. D. Vought, 95 Liberty St., New York.

Northern Railroad Club (Duluth).—The paper scheduled for the next meeting, Saturday evening, April 24, is on "The Consumption of Fuel and Oil on Locomotives" by Frank Burk, traveling engineer, D. M. & N. Ry.

The February meeting was given up to a continuation of the discussion on the papers presented at the January meeting on Concrete and Steel Ore Docks and Boiler and Engine Repairs in Roundhouses. A large part of the discussion swung around the advantages and disadvantages of pooling locomotives.

Secretary, C. L. Kennedy, 401 West Superior St., Duluth, Minn.

Railway Club of Pittsburgh.—The meeting on the evening of April 23 will be to consider a paper on "Titanium Alloy" by Charles V. Slocum.

The report of the standing committee on the M. C. B. Rules of Interchange was quite extensive, a large number of suggestions for the improvement of rules being offered and thoroughly discussed by the members. The results of the committee's and club's effort, will appear at the convention of the M. C. B. Association.

Secretary, C. W. Alleman, P. & L. E. R. R., Pittsburgh.

Richmond Railroad Club.—A stereopticon lecture by H. O. Williams, railroad secretary of the International Committee of the Y. M. C. A., entitled "Welfare Work of American Railways", will be given at the meeting of April 12.

The March meeting was entertained by W. Morris-Tye, who demonstrated and fully explained the Burlingame telegraphic typewriter, which sends telegraphic messages by simply operating the keys of a typewriter.

Secretary, F. O. Robinson, Richmond, Va.

St. Louis Railway Club.—The next regular meeting of the club will be held in the parlors of the Southern Hotel on Friday, April 7, at which time a paper will be presented by H. Wade Hibbard, Professor of Mechanical Engineering, University of Missouri, entitled "Organization." This will be the last meeting of the year and the officers will make their annual report. New officers will also be elected.

Secretary, B. W. Frauenthal, Union Station, St. Louis, Mo.

Western Canada Railway Club (Winnipeg, Man.)—This last addition to the railway club circle has already over 150 members and bids fair to be a complete success. The first regular meeting was held on the evening of March 8, the paper being by G. J. Burry, general manager of the Western Lines of the Canadian Pacific Railway, on "A Review of Organization and Some Suggestions." The paper considered the history of labor organization down to the present time and very comprehensively discussed the labor problem on railways.

The active officers of this club are: President, Grant Hall, superintendent of motive power of the C. P. Ry.; vice-president, A. E. Cox, general storekeeper of the C. N. Railway; second vice-president, L. B. Mirriam, division chief engineer of the G. T. P. Railway; treasurer, E. Humphreys.

Secretary, W. H. Rosevear, 199 Chestnut St., Winnipeg, Man.

Western Railway Club (Chicago).—The meeting of April 20 will be given up to a discussion of the report of the Committee on Revision of Rules of Interchange and also a short paper on "The Influence of Ash on the Value of Coal in Locomotive Service" by A. Bement.

The meeting of March 17 was taken up by a discussion of the paper on "Publicity for Railroad Accidents." It was largely attended and the paper was very fully discussed by W. G. Bessler, general manager, C. R. R. of N. J.; W. B. Throop, general superintendent of the Iowa District of the C. B. & Q. R. R.; W. D. Cantillon, assistant general manager of the C. & N. W. Railway; C. E. Lee, gen. supt. of the B. & M. R. R., and others.

Secretary, J. W. Taylor, Old Colony Bldg., Chicago.

MEETING OF THE INTERNATIONAL RAILWAY FUEL ASSOCIATION.—The first annual meeting of this association will be held in the Auditorium Hotel, Chicago, June 21, 22 and 23. At this meeting papers on the following subjects will be presented by the various committees for discussion: "Proper Method of Purchasing Fuel with Regard to Operating and Traffic Conditions, Considering also the Permanent Interests of the Producer When Located on the Consumers' Rails"; "Standard Type or Types of Coaling Stations, Best Design and Most Economical Coal Chute for Handling Coal from Cars to Locomotives"; "Best Method of Accounting for Railway Fuel, Including Movement from Mine Through Coaling Station to Engines, up to Monthly Balance Sheet"; "Difference in Mine and Destination Weights, Legitimate Shrinkage Allowable on Car Lots, Correct Weighing of Coal at Mines and on Railroad Track Scales, Importance of Tare Weights Being Correct"; "Difficulties Encountered in Producing Clean Coal for Locomotive Use." D. B. Sebastian, 327 La Salle Street Station, Chicago, is secretary.

NEW LOCOMOTIVE AND CAR SHOPS.

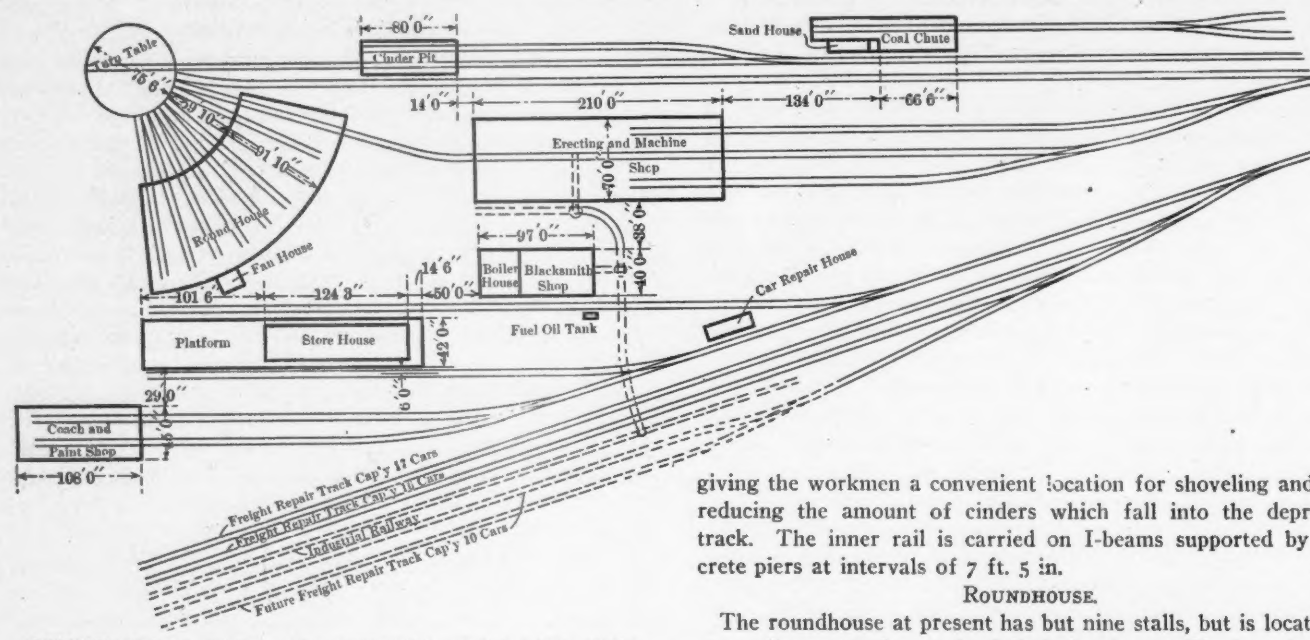
IDAHO & WASHINGTON NORTHERN RAILWAY.

The new shops of the Idaho & Washington Northern Railway at Spirit Lake, Idaho, which were completed and put into operation last November, are designed to handle heavy repairs on about 40 locomotives annually. The railroad is equipped with the heaviest type of ten-wheel and consolidation locomotives and is being extended at present so that the shops are shortly expected to be worked at full capacity. They are also designed for easy extension and enlargement in case their present capacity is exceeded at any time. The same features apply to the repair of passenger equipment, for which a special building is provided.

In the general arrangement of the buildings, shown in one of the illustrations, the roundhouse and facilities for turning engines naturally takes precedence, and since, from the topography of the country, the shops had to be placed between the main line of the road and a hill side it was decided to locate the shop buildings between the main tracks and a straight lead to the roundhouse. As the buildings are comparatively few in number and of moderate size, this idea worked out very nicely.

Because of the comparatively high cost of steel in that region and the cheapness of timber, as small an amount as possible of the former material was used in the construction of the buildings. The structures throughout are of brick walls resting on concrete foundations with wooden roofs supported by wooden roof trusses. In the roundhouse the walls of the outer circle are carried up to a height of five feet above the floor, above which they are continued as pilasters for supporting the roof, I-beams being used as lintels. Concrete has been extensively used for pits, heating ducts, cinder pits and other places where its advantages apply.

Unusual care has been given to obtaining the maximum amount of natural lighting in all buildings. Pivoted sashes, fitted with operating mechanism for swinging, are used wherever desirable. This feature is especially noticeable in the roundhouse where nearly 60 per cent. of the outer circle is given up to windows in addition to 100 sq. ft. per pit of window area over the doors on the inner circle and three large windows in the end walls. There are 18 swinging sash between each two pilasters in the outer wall, 6 stationary sash over the doors and 9 swinging sash in each of the end wall windows. This gives, as can be seen in the illustration, a very light and pleasant roundhouse.



ARRANGEMENT OF TRACKS AND BUILDINGS, SPIRIT LAKE SHOPS, I. & W. N. RY.

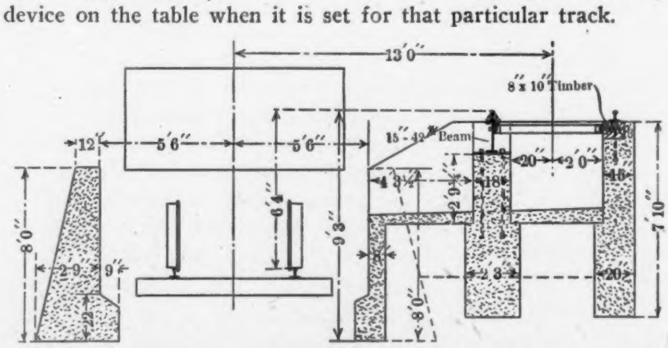
COAL CHUTE AND CINDER PIT.

On the approach tracks to the roundhouse is located a coal chute providing ten 5-ton pockets filled by gravity from a storage bunker of 175 tons capacity. The loaded coal cars are drawn up the 19 per cent. incline by a motor driven hoist and dumped directly into the storage pockets. This is a wooden structure and includes the sand house, which is provided with a compressed air elevating device, allowing the locomotive sand boxes to be filled by gravity.

Between the coal chute and the roundhouse on the same lead track is located the cinder pit, a section of which is shown in one of the illustrations. This is constructed of concrete throughout and is of the hand operated type. The bottom of the pit is extended outside the inner rail to make a ledge about 4 ft. wide, giving the workmen a convenient location for shoveling and also reducing the amount of cinders which fall into the depressed track. The inner rail is carried on I-beams supported by concrete piers at intervals of 7 ft. 5 in.

ROUNDHOUSE.

The roundhouse at present has but nine stalls, but is located so as to allow extension to the full circle of 44 stalls. A 75 ft. turntable in a concrete pit is provided, having two lead tracks for locomotives, one passing the coal chute and over the cinder pit and the other, for outgoing engines, located parallel to this and between it and the shops. The turntable is hand operated and is provided with a very complete set of interlocking derail devices for preventing runaway locomotives from dropping into the pit. These consist of a derail on each roundhouse track at a distance of 20 ft. from the turntable and on the lead tracks at a distance of 50 ft. from the pit. These derails are normally in operating position and can be thrown out only by the locking device on the table when it is set for that particular track.



SECTIONAL ELEVATION OF CINDER PIT.

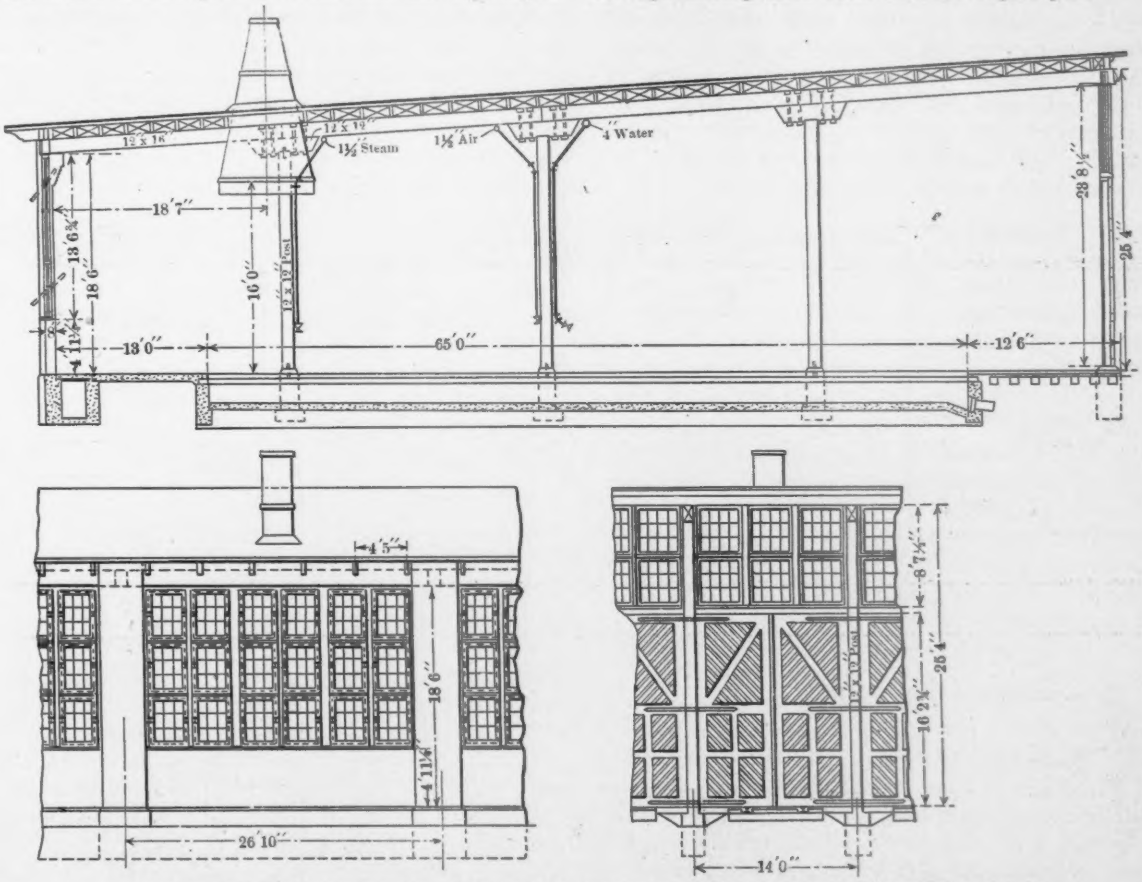
Provision for handling heavy pieces of machinery and driving wheels directly from the roundhouse to the machine shop is made by extending one of the roundhouse tracks through the

INTERIOR VIEW OF ROUNDHOUSE, IDAHO AND WASHINGTON NORTHERN RY.

outer wall, connecting it to the track which runs through the machine shop.

The cross section of this roundhouse, shown in one of the illustrations, gives its dimensions and general features very clearly. The roof has a continuous drop from the inner circle toward the outer wall and is supported by three rows of intermediate posts. The pits are of concrete, draining toward the inner end. The floor is of concrete and is slightly sloped to drain into the pits, permitting the house to be kept clean with minimum expense, in addition to making the trucking of heavy parts comparatively easy.

A 4 in. water, 1½ in. air and a 1½ in. steam line are carried along the roof; the latter two having a connection at the posts between each two stalls and the water at every second stall. The doors are of a heavy framed wooden type and swing outward. The workmen's benches and lockers are placed between the stalls at the outer row of posts, giving a clear passage around the house along the outer wall. Drop pits for driving and truck wheels are provided, being fitted with hydraulic and pneumatic drop pit jacks respectively. The heating of the house is by the indirect system, a small building adjoining the outer wall containing the heating coils and fans, which deliver the hot air through underground ducts into the engine pits.



ELEVATIONS AND SECTION OF ROUNDHOUSE, IDAHO AND WASHINGTON NORTHERN RAILWAY.

MACHINE AND ERECTING SHOP.

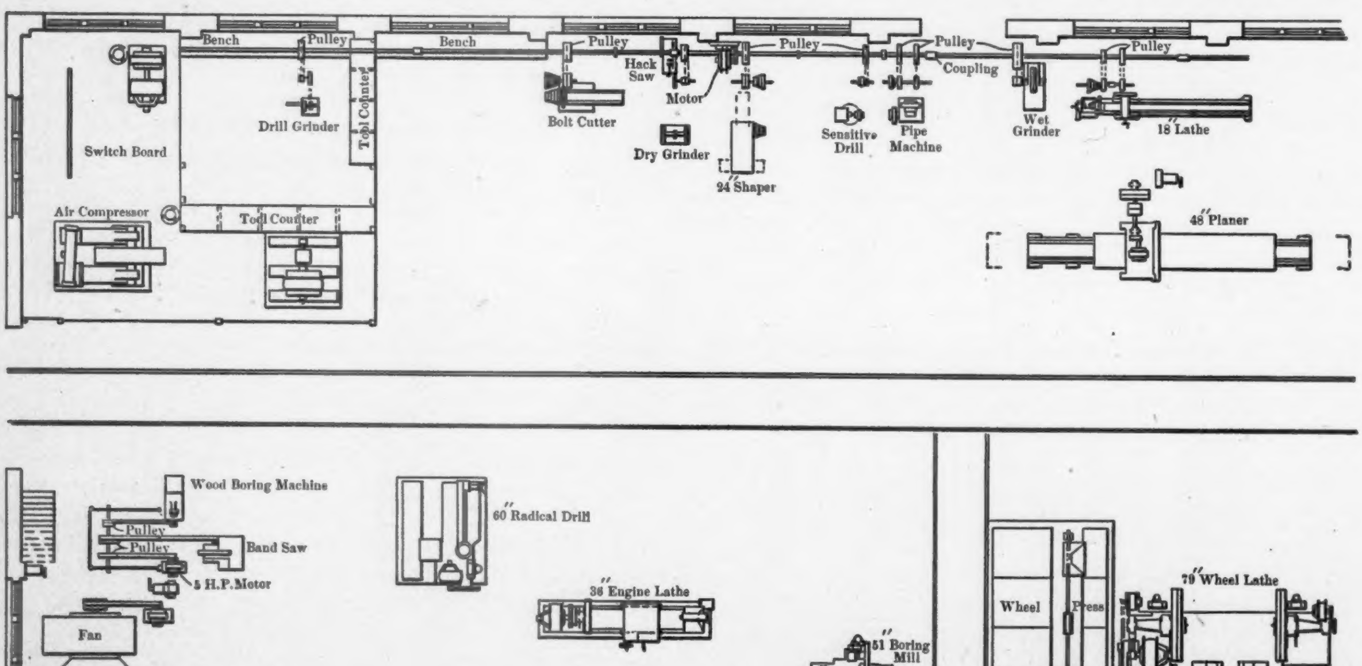
This shop occupies a building 210 x 70 ft., the entire area of which is served by a 10-ton, three-motor, electric crane, arranged to be operated either from a cage or by pendant cords extending to the floor. In it will be done all of the locomotive

INTERIOR VIEW OF MACHINE AND ERECTING SHOP, IDAHO AND WASHINGTON NORTHERN RY.

chine and erecting work, as well as the boiler work, with the exception of the flues, which are handled in the blacksmith shop. Several wood-working tools are also included in the equipment of this shop.

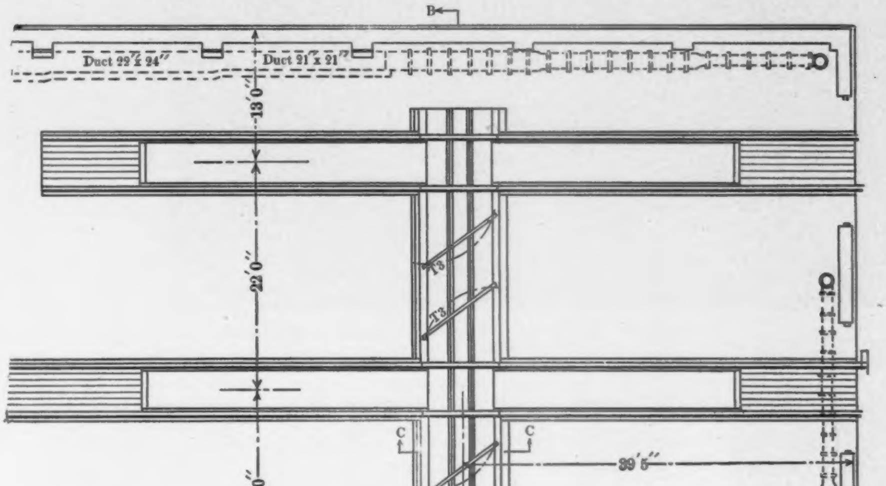
The erecting shop occupies three pits at one end of the building, the track over the center pit extending throughout the length of the building and into the roundhouse as above mentioned. These three pits are served by a common drop pit containing a 30-ton hydro-pneumatic transfer jack. One of the illustrations shows the construction of this drop pit, the design of which was given close attention with the idea of making it thoroughly reliable and rapid in its action. The removable sections of the running rails over the drop pit are carried on 15 in. I-beams, the whole being hinged at one end and sliding on a guide, so that they can be quickly and easily removed, or replaced. This pit, if desired, can be used for removing and replacing the truck as well as the driving wheels. The locomotives are then either supported on blocks or special trucks, depending upon whether circumstances allow it to be stripped over the pit or not. Actual practice has shown that a locomotive can be wheeled with this arrangement as quickly as it could, under normal conditions, be transferred from another part of the shop and set down on its wheels by overhead cranes.

The location and arrangement of the machine tools in this shop are shown in one of the illustrations. The drive is by electric motor in all cases, the smaller tools being grouped along the east wall and driven from a line shaft supported by timbers carried on the wall and located so as to minimize the obstruction of light from the windows. The larger tools, consisting of a 48 in. planer, a 36 in. lathe, 51 in. boring mill, 60 in. half universal



PLAN OF MACHINE SHOP SHOWING LOCATION OF MACHINE TOOLS, SPIRIT LAKE SHOPS, I. & W. N. RY.

radial drill, 79 in. driving wheel lathe with double quartering attachments and a 400-ton wheel press, are driven by individual motors. The wheel press is set in a covered pit of such depth that the ram is at a height above the floor suitable for pressing on and off car and truck wheels. By removing the pit cover, driving wheels are handled in the same press. The boring mill has a chuck on the table and is used for boring car wheels as well as for general work. It is equipped with a jib crane and air hoist for handling work from the floor. The smaller tools consist of an 18 in. lathe, a 24 in. shaper with an attachment for slotting driving boxes and with index centers, a 2 in. bolt cutter with lead screws for cutting staybolts, a 3/4 in. high speed drill



PLAN OF ERECTING PITS AND DETAILS OF DROP PIT, SPIRIT LAKE SHOPS.

press, a 4 in. pipe machine, twist drill grinder, power hack saw and wet and dry grinders. In addition to this there is a band saw and a single spindle wood borer, both of which are driven by a single motor set on the floor.

The tool room enclosure is located in one corner of the shop, at the end opposite the erecting shop. A 500 cu. ft. two-stage motor driven air compressor is located inside of the tool room, being operated automatically by means of an unloading device. In this same space is also located the motor generator which supplies direct current for the variable speed motors driving machine tools and for the crane motors. The power for the shops is supplied by a three-phase 440-volt current from an outside source. Since this electric equipment requires practically no attention, the same holding true for the air compressor, the services of an engineer are not required and this machinery is watched and cared for by the man in charge of the tool room.

In the opposite corner of the building are located the radiators and fans for the heating system, and over these, on an enclosed platform, are the lockers and toilets for shop employees.

This shop has a concrete floor, the same as the roundhouse, and presents the same advantages. The heating is by hot air through underground concrete and tile pipe ducts, a motor driven 120-in. fan giving circulation. The lighting is by arc lights freely distributed along the roof trusses and the usual incandescent lights at the machines, plugs for portable lights also being frequent.

BLACKSMITH SHOP.

The blacksmith shop and boiler plant are located in a building 97 ft. long by 40 ft. wide, the former taking up 65 ft. of the south end. The equipment in this shop consists of one 1,100 lb. steam hammer, a single ended motor driven punch and shear, and three forges, one of them being extra large. A 3 ton jib crane serves the hammer, the punch and the large forge. One corner of this building is used as a flue shop and is equipped with a motor driven flue cutter and oil flue welding furnace and a pneumatic flue welder. Space outside of the building has been provided for a flue rattler.

Since the shops obtain power from an outside source there is no necessity for a power house, but steam is required for heating the various buildings and the coaches in the coach yard, for operating the steam hammer and for roundhouse uses. Therefore a boiler plant, consisting of two 125 h. p. horizontal return tubular boilers, which burn either coal or refuse wood, has been installed in one end of the blacksmith shop building, the two rooms being separated by a brick wall. This locates the boilers at about the center of the group of shop buildings.

STOREHOUSE AND OFFICE BUILDING.

The storehouse is a brick building 124 x 30 ft. in the south end of which are the offices of the mechanical department, and, at the north end, a fireproof oil cellar. The metal oil tanks in this cellar are filled from the level of the storeroom floor, and the oil is distributed from a delivery counter, to the level of which the various kinds of oil are lifted by self-measuring pumps.

The storehouse platform extends all around the building at the same level as the storehouse floor; or at the height of the average car floor. At the north end of the building the platform is extended out 100 ft. from the building wall with the full width of 42 ft.

PAINT AND COACH SHOP.

This building is intended for general use in repairing, cleaning and painting passenger cars. It is 108 ft. long and 45 ft. wide with two longitudinal tracks extending nearly the whole length of the building. The roof has longitudinal skylights extending along the center line to give ample light between the tracks. The floor is of concrete and is sloped in accordance with an underground system of drains in order to permit washing of coach bodies and trucks. Along the walls at the north end are sinks for washing the removable parts and the drying racks for sashes, doors, ventilators and seat arms. Trussed planks resting on ladder horses are provided for painting or repairing coach sides.

COACH AND FREIGHT CAR YARD.

Owing to the ordinarily mild climate at Spirit Lake, the freight car repairs are made outside, on tracks west of the blacksmith shop. A car repairman's house 40 x 12 ft. is located alongside of the repair tracks, for housing tools and clothes. A line of piping for compressed air is run along the tracks with hose connections for compressed air drills and hammers. The coach yard has two tracks between which are service boxes at intervals of 50 ft., containing steam, water and air connections. Standard gauge industrial tracks are provided for handling mounted wheels and transporting heavy material between the machine shop and repair tracks and the blacksmith shop.

WATER SERVICE AND SEWERS.

The high cost of cast iron pipe in this locality made the use of iron water mains undesirable, and as the soil at the shop is a dry gravel, wooden water pipe was installed throughout the shop yards. Fire hydrants are arranged about the yard; and in addition two hose houses, each containing a hose reel on a truck and a supply of fire hose, have been provided. In the interior of each building hose valves and reels of fire hose have been provided so that fires originating inside of the building may be properly attacked.

Owing to the fact that seepage through the soil is very rapid, the roundhouse, turntable and cinder pit drain into a sump pit. The sanitary sewers from the machine shop and storenouse are connected through a manhole to a city sewer running near the shops.

CONSTRUCTION.

The preliminary work for the plans of the shops was taken up in May, 1908, and construction was begun the latter part of June.

All buildings and equipment were turned over to the railroad company for operation, early in November, 1908.

The shops were designed and built, and all the equipment was furnished and installed, including even all hand tools necessary to make the shops complete and ready for operation, by Westinghouse, Church, Kerr & Co., engineers, under the supervision of R. F. Blackwell, vice-president and general manager, and W. C. Smith, chief engineer of the Idaho & Washington Northern Railroad.

CLEANING AND REPAIRING TRIPLE VALVES.

The cleaning and repairing of triple valves may be greatly facilitated by providing a special bench, such as shown in the illustrations. This bench is in use at the east-bound freight car repair yard of the Pennsylvania Railroad at Altoona. Two men may work at the bench at the same time, one at each end.

The triple valve is placed on the bench, as shown in Fig. 2; a pin fits into one of the bolt holes in the flange of the triple and the two clamps fit over the flange. These clamps are held firmly against the flange by a spring in the socket of the clamp and underneath the nut. The clamps may be quickly adjusted or released with the hands. The pin keeps the triple valve from turning and can be quickly removed and placed in other holes provided for receiving the different size triple valves. The old way of holding the triple valve on the bench with two pins, one on each side of the valve, was unsatisfactory, as it was not held firmly enough; with the new bench it is only necessary to have one pin, as there is a hole cut through the tilting table large enough to fit the projection on the bottom of the triple, which answers for the second pin.

While in the position shown in Fig. 2 the bolts are removed and the check valve case which projects forward and the cylinder cap which projects upward, are removed, as shown in Fig. 3.

The check valve case is dropped into and fits snugly in an opening which is cut in the edge of the bench to the left of the tilting portion upon which the triple valve is fastened. The check valve case is thus held firmly in position while the train line check valve is being ground in.

FIG. 2.—TRIPLE VALVE CLAMPED TO BENCH.

FIG. 4.—TRIPLE VALVE TILTED BACKWARD.

In order to carefully examine the space in the triple valve body between the emergency valve piston and the emergency valve and its seat, that portion of the table upon which the valve is carried is tilted backward, as shown in Fig. 4. This is accomplished by pressing the treadle alongside the bench with the foot, thus withdrawing the pin that locks the tilting portion, which when tilted locks itself in any one of a number of differ-

FIG. 1.—BENCH FOR CLEANING AND REPAIRING TRIPLE VALVES.

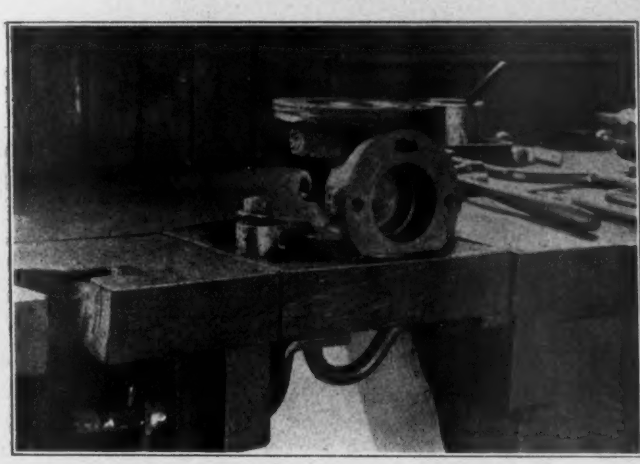


FIG. 3.—CHECK VALVE CASE AND CYLINDER CAP REMOVED.

FIG. 5.—TRIPLE VALVE TILTED FORWARD.

ent positions, at the will of the operator. While in this position the feed groove in the upper wall of the triple piston cylinder is exposed to the light and can be thoroughly cleaned. In order to properly clean this feed groove on the old bench it was necessary to remove the valve from the pins and turn it over to the light. The feed groove is very small and must receive careful attention, as the air that charges the auxiliary reservoir passes through it.

To clean the cylinder and the slide valve bushing the table is placed as shown in Fig. 3. After this is completed the table is tilted forward, as shown in Fig. 5. The light reflected from the chute underneath makes it possible to examine the bushing properly. This being done the table is again placed as in Fig. 3 and all lint from the waste, which may have adhered to the valve, is blown out with compressed air. The parts of the valve are then reassembled.

NOISELESS GEARS.

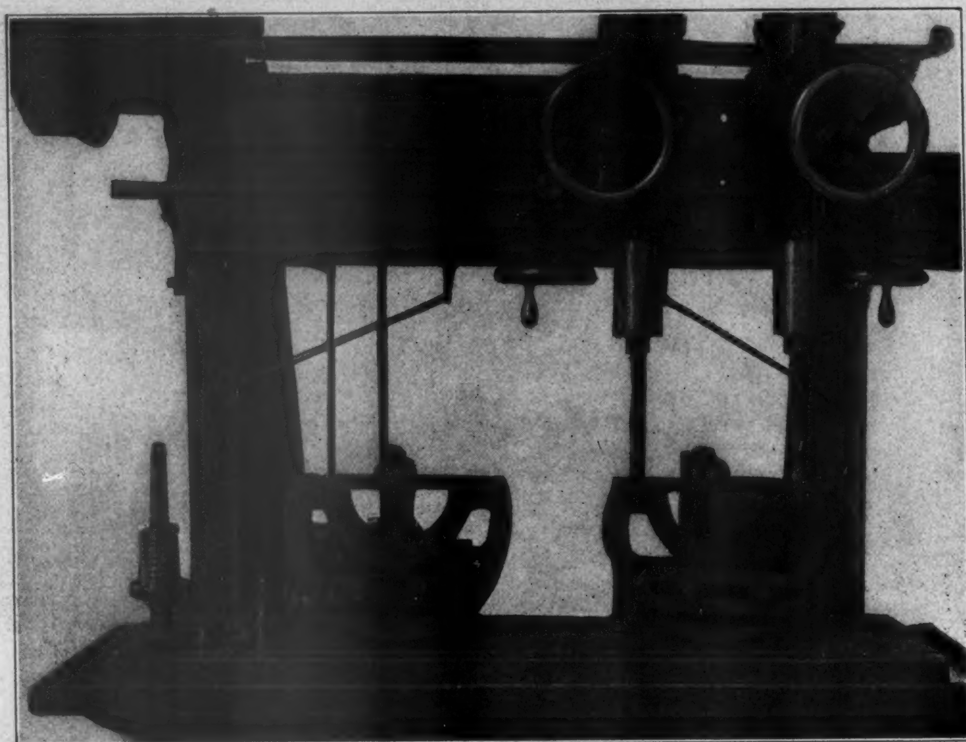
The introduction of motor driven machine tools has in many cases been accompanied by at least one disadvantage. This to be sure is minor when compared with the advantage derived in other ways, but nevertheless it is a decided and noticeable fault and one which is not at all necessary. Reference is made to the nerve racking noise which develops after metal gears running at high speeds have been in operation long enough to lose their perfect contour.

It is true that attention must be given to durability at these points and that the ordinary rawhide gears and some gears of special composition have not proven satisfactory, but that does not mean that the men studying this feature have given the problem up as insolvable. They have not by any means, and for many purposes they have actually solved it. Gears can be obtained which are noiseless in operation, and while they won't outwear the steel gears with which they mesh, they will last long enough to be entirely practical from a durability and cost standpoint.

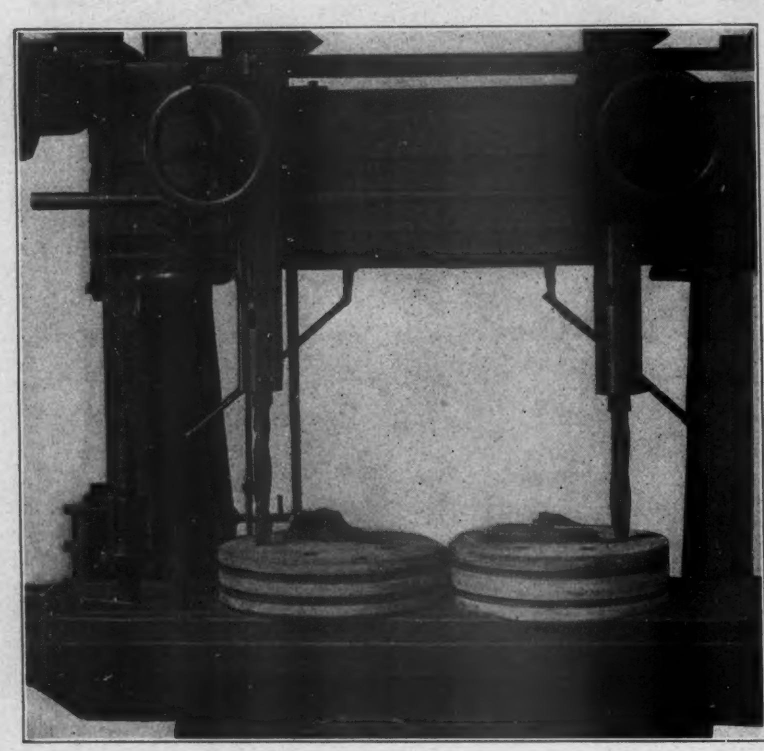
The great advantage of such gears will be readily appreciated by those who have to spend any time in the neighborhood of machine tools, electrically driven through steel gears, which have been in operation a few months, and while the value of less noise is hard to estimate in dollars and cents, no one denies that it has a very real value judged on that standard.

A 1,200 VOLT DIRECT CURRENT ELECTRIC RAILWAY

The Pittsburgh, Harmony, Butler & New Castle Railway, which was recently opened with 65 miles of single track and double track for 11½ miles, employs direct current of 1,200 volts pressure at the trolley wire. This is said to be the pioneer high tension direct current road of the country, although it is not the first to be actually put into operation. Grooved 0000 trolley wire is used, strung double over the entire line. The road is operating fourteen four-motor passenger cars of the usual interurban type and will shortly put into service several freight cars.



DRILLING ECCENTRICS.



DRILLING PISTON HEADS.

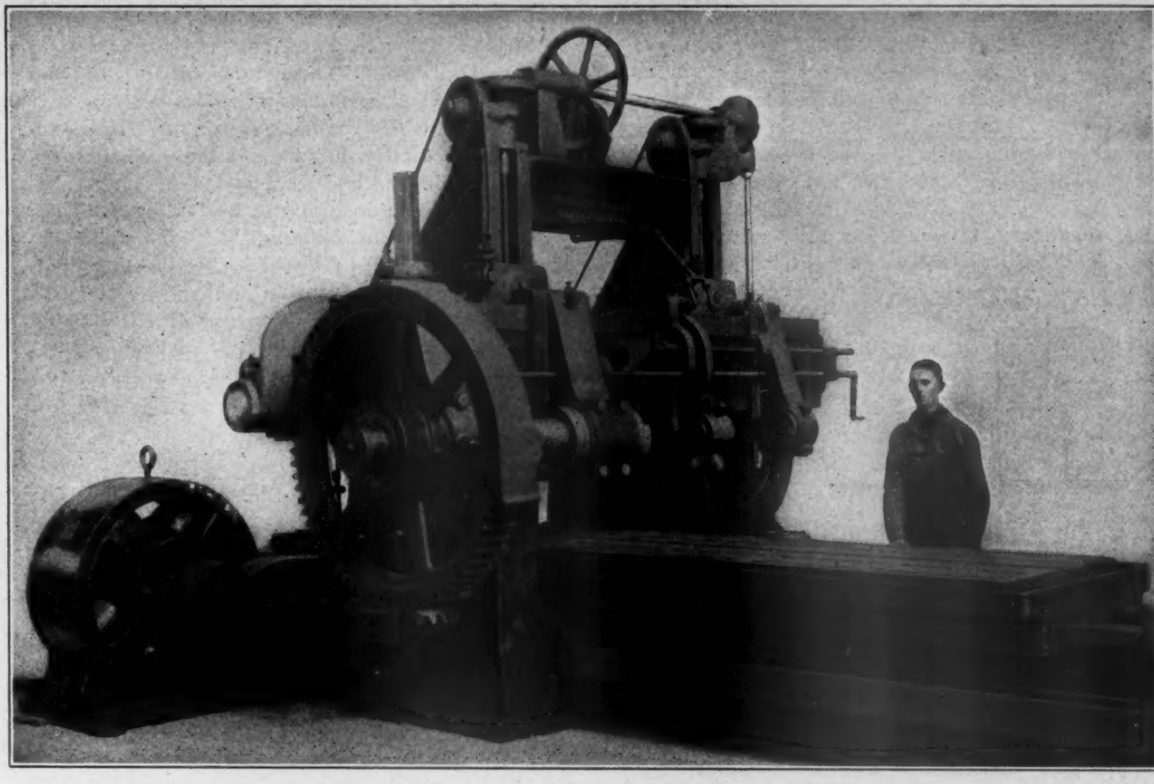
DRILLING SPRING SADDLE.

MULTIPLE SPINDLE DRILLS IN RAILROAD SHOPS.

Several typical operations, which may be performed to advantage on a multiple spindle drill in a railroad locomotive repair shop, are shown in the accompanying illustrations. Two 1½ in. holes are being bored in the spring saddle at the rate of 1¼ in. per minute. The machine upon which the work is being done measures 49½ in. between uprights; the minimum distance between the center of the spindles is 8 in. and the maximum 48 in. The table has a vertical adjustment of 12 and the maximum distance from the nose of the spindle to the top of the table is 24 in. The heads are independent in drive and feed.

The two holes are drilled and tapped in one eccentric while the other one is being clamped to the table. The third illustration shows the method of drilling and tapping piston heads. The machine used is made by The Foote-Burt Company, as is indicated by the ball bearing thrust bearings on the spindle.

Jib Crane in Roundhouses.—In most modern engine houses there are one or more columns between the tracks, and the one at the front of the engine should be utilized for a jib crane of about 2,000 pounds capacity. This will be found of great assistance in handling stacks, fronts, bells, air pumps, steam chest lids, etc. A differential chain block hung on a trolley will be found to answer all requirements.—*Wm. Elmer, Ry. Club of Pittsburg.*



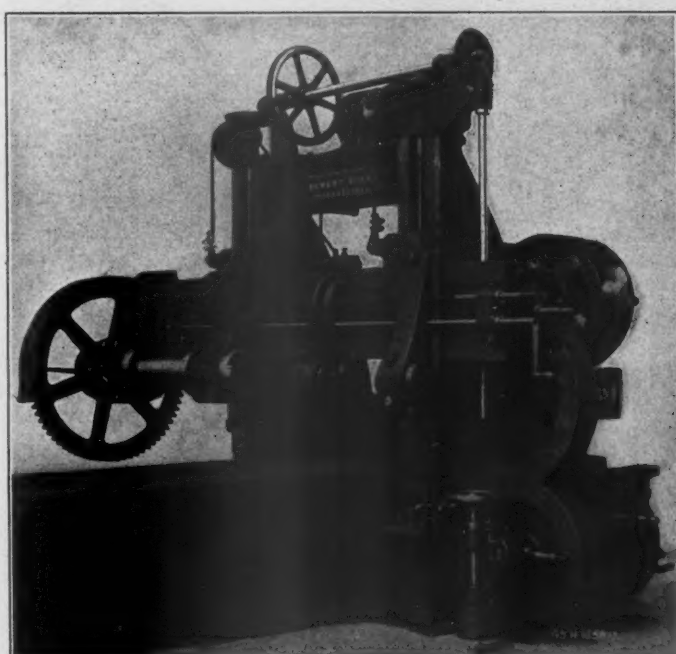
HEAVY MILLING MACHINE FOR CONNECTING AND SIDE RODS.

EXTRA HEAVY ROD MILLING MACHINE.

The 48-inch milling machine, shown in the illustrations, is exceptionally powerful and was specially designed for milling locomotive connecting and side rods in pairs. It is driven by a 65 h.p. motor with a two to one speed range. This furnishes all the speeds necessary for milling rods, but motors of different speed ranges or greater power may be applied to suit other conditions. This machine has removed 82 cubic inches of steel per minute, but with a larger motor than noted above.

The machine measures 48 in. between the housings and the maximum distance from the center of the spindle to the table is 36 in. The spindle is 8 in. in diameter, except for that part to which the cutter mandrel is locked, which is enlarged to 12 in. in diameter. There is a horizontal adjustment for locating the cutters and a central bearing for supporting the mandrel between the cutters.

The table is 40 in. wide on its working surface and is usually made 14 ft. between the end pans, although this may be changed to suit requirements. A trough is cast around the table for collecting the cutting lubricant; this drains to a lower receptacle from which it is pumped to a tank by a power driven pump. The table is fed by a separate 7 h.p. variable speed motor, so wired with the driving motor that it stops when current to the driving motor is cut off. This motor also drives the table fast power traverse. By using this separate feed motor a great variety of table feeds are instantly obtainable without changing the cutting speed, and both may be adjusted to get the maximum output of both the cutters and the machine. This machine is made at the Bement Works of the Niles-Bement-Pond Company.



OPERATING SIDE OF ROD MILLING MACHINE.

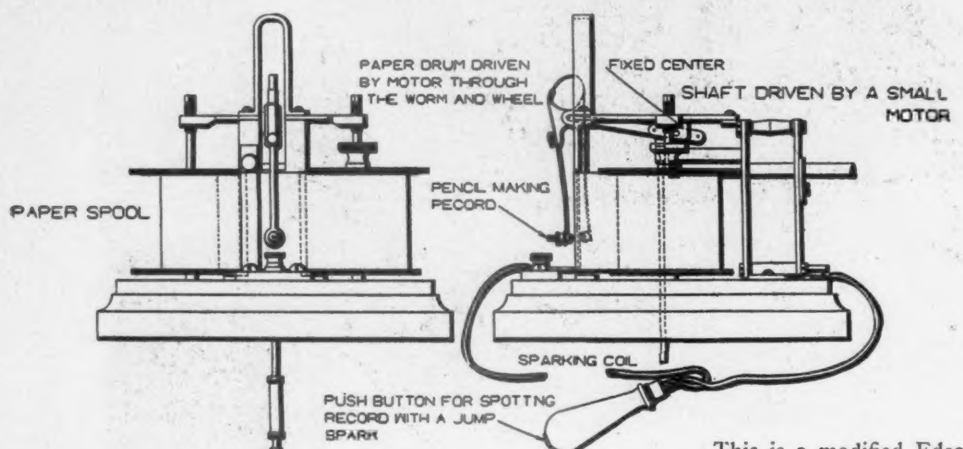
"Track Skate."—In regard to preventing engines from running into the pit, we have a very simple device which seems to have answered the purpose. It is a steel casting which we call a track skate. It has a thin edge which lies on top of the rail and the flange keeps it from shifting sideways, and the end is turned up 6" or 8" so that in case the engine starts to move into the pit the tender wheel rides on this track skate and pushes it along and it acts as a very effective brake.—*Wm. Elmer before the Railway Club of Pittsburgh.*

Forest Products Laboratory.—The government's new forest products laboratory will be located at the University of Wisconsin, at Madison. The establishment of this laboratory means the concentration of all lines of the experimental utilization of timber and the checking of wood waste. Forest Service laboratories for timber test work at Yale and Purdue Universities and the government's wood pulp and wood chemistry laboratory in Washington will be consolidated and transferred to Madison as soon as practicable. A force of fifteen to twenty timber test engineers, experts in wood preservation, wood pulp manufacture and wood distillation will have charge of the work carried on. The laboratory will have an equipment valued at not less than $15,000. The University will furnish the building, light, heat, and power, and in return advanced students will have the use of the laboratory for special work in related lines.

SAFETY VALVE CAPACITY*

PHILIP G. DARLING,† Assoc. Amer. Soc. M. E.

The function of a safety valve is to prevent the pressure in the boiler to which it is applied from rising above a definite point, to do this automatically and under the most severe conditions which can arise in service. For this, the valve or valves must have a relieving capacity at least equal to the boiler evaporation under these conditions. If it has not this capacity, the boiler pressure will continue to rise, although the valve is blowing, with a strain to the boiler and danger of explosion consequent to over-



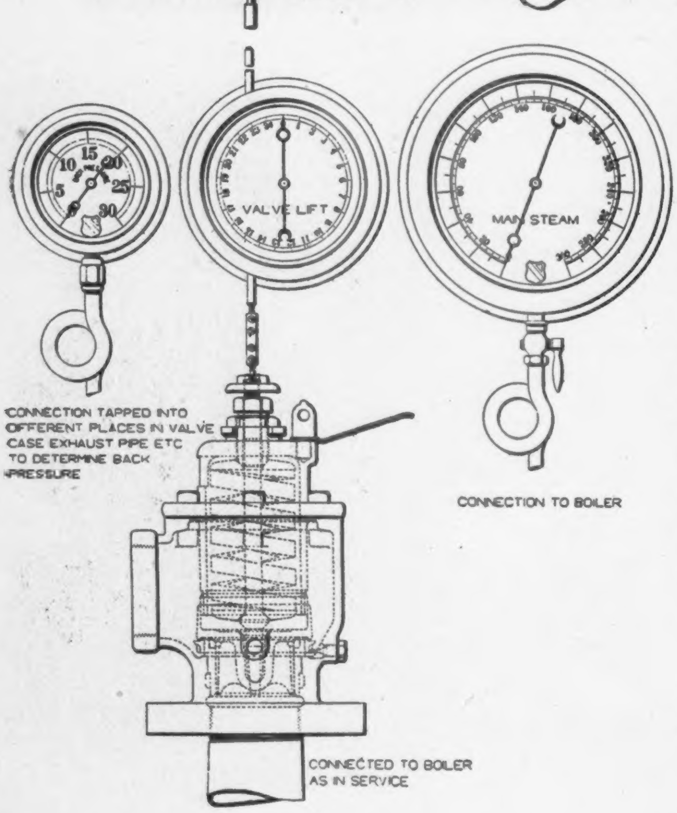


FIG. 2.—ARRANGEMENT OF APPARATUS TO GIVE VALVE LIFT DIAGRAM.

pressure. Thus with the exception of a requisite mechanical reliability, the factor in a safety valve bearing the most vital relation to its real value is its capacity.

Two factors in a safety valve geometrically determine the area of discharge and hence the relieving capacity—the diameter of the inlet opening at the seat and the valve lift. The former is the nominal valve size, the latter is the amount the valve disc lifts vertically from the seat when in action. In calculating the size valves to be placed on boilers, rules, which do not include a term for this valve lift, or an equivalent, must necessarily be derived from the basis of a certain lift assumed for each size of valve. Nearly all existing rules and formulæ are of this kind and rate all valves of the same nominal size as of the same capacity.

To find what lifts standard make valves actually have in practice and thus test the truth or error of this assumption that they are approximately the same for the same size valve, an apparatus has been devised and tests upon different makes of valves conducted. With this apparatus not only can the valve lift be read at any moment to thousandths of an inch, but an exact permanent record of the lift during the blowing of the valve is obtained in a form somewhat similar to a steam engine indicator card (Fig. 1) and of a quite similar use and value in analyzing the action of the valve.

As appears in Figure 2 the valve under test is mounted upon the boiler in the regular manner, and a small rod is tapped into the top end of its spindle and connects the lifting parts of the valve directly with a circular micrometer gauge, the reading hand of which indicates the lift upon a large circular scale or dial. The rod through this gauge case is solid, maintaining a direct connection to the pencil movement of the recording gauge above. This is a modified Edson recording gauge with a multiplication in the pencil movement of about 8 to 1, and by means of a chart drum driven by a small electric motor (not shown), gives a horizontal time element to the record. The steam pressures are noted and read from a large test gauge and an electric spark device makes it possible to spot the chart at the different pound pressures during the blowing of the valve. The actual lift equivalents of the pencil heights upon the chart are carefully calibrated so the record may be accurately measured to thousandths of an inch.

With this apparatus, investigations and tests were started upon seven different makes of 4 inch stationary safety valves, and these were followed with similar ones upon nine makes of muffler locomotive valves, six of which were 3½ inches, all of the valves being designed for and tested at 200 lbs. The stationary valve tests were made upon a 94 h. p. water tube boiler from the Babcock & Wilcox Co. The locomotive valve tests were made upon locomotive No. 900 of the Illinois Central R. R., the valve being mounted directly upon the top of the main steam dome. This locomotive is a consolidation type, having 50 sq. ft. of grate area and 2,953 sq. ft. of heating surface. Although a large amount of additional experimenting has been done only the results of the above will be quoted in this paper. These lift records show (with the exception of a small preliminary simmer which a few of the valves have) an abrupt opening to full lift and an almost equally abrupt closing when a certain lower lift is reached. Both the opening and closing lifts are significant of the action of the valves.

The results of the 4 inch iron body stationary valve tests summarized are as follows: Of the seven valves the average lift at opening was .079 in. and at closing .044 in., or excluding the valve with the highest lifts, the averages were .07 in. at opening and .037 in. at closing. The valve with the lowest lifts had .031 in. at opening and .017 in. at closing, while that with the highest had .137 in. and .088 in. Of the six 3½ in. muffler locomotive valves the summarized lifts are as follows: Average of the six valves .074 in. at opening and .043 in. at closing. Average, excluding the highest, .061 in. at opening and .031 in. at closing. The lowest lift valve had .04 in. opening and .023 in. closing; the highest .140 in. opening and .102 in. closing.

The great variation—300 per cent.—in the lifts of these standard valves of the same size is startling and its real significance is apparent when it is realized that under existing official safety valve rules these valves, some of them with less than one-third

* Presented before a meeting of the American Society of Mechanical Engineers, Feb. 23, 1909.

† Mechanical Engineer, Consolidated Safety Valve Co.

the lift and capacity of others, receive the same rating and are listed as of equal relieving value. Three of these existing rules are given below as an illustration of their nature:

RULE OF THE UNITED STATES BOARD OF SUPERVISING INSPECTORS.

$$A = .2074 \times (W \div P)$$

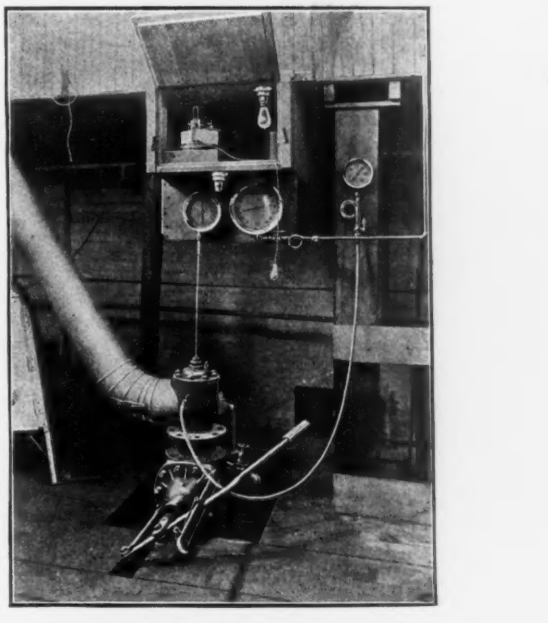
A = area of safety valve in sq. in. per sq. ft. of grate surface.
W = lbs. of water evaporated per sq. ft. of grate per hour.
P = boiler pressure (absolute.).

In 1875 a special committee was appointed by this Board to conduct experiments upon safety valves at the Washington Navy Yard. Although the pressures used in these experiments (30 to 70 lbs. per sq. in.) were too low to make the results of much value to-day, some of the conclusions reported are significant.

"First: That the diameter of a safety valve is *not* an infallible test of its efficiency.

"Second: That the lift which can be obtained in a safety valve, other conditions being equal, *is* a test of its efficiency."

The present rule of the Board as given above, formulated by L. D. Lovekin, Chief Engineer of the New York Shipbuilding Co., was adopted in 1904. Its derivation assumes practically a 45 degree seat and a valve lift of 1/32 of the nominal valve diameter. The discharge area in this rule is obtained by multiplying the valve lift ($D \div 32$) by the valve circumference ($\pi \times D$) and taking but 75 per cent. of the result to allow for the added restriction of a 45 degree over a flat seat. The 75 per cent. equals approximately the sine of 45 degrees or .707. This value for the discharge area, *i. e.* ($.75\ \pi\ D^2 \div 32$), is substituted directly into Napier's formula for the flow of steam.



LIFT TESTING APPARATUS ON STATIONARY BOILER.

Thus in the valves to which this rule is applied the following lifts are assumed to exist:

1 in. valve... .03 in.	3 in. valve... .09 in.	5 in. valve... .16 in.
2 in. valve... .06 in.	4 in. valve... .13 in.	6 in. valve... .19 in.

Referring to the valve lifts obtained by the tests, it is seen that the highest lift agrees very closely with the lift assumed in the rule and if the valve lifts of the different designs were more uniformly of this value or if the rule expressly stipulated either that the lift of 1/32 of the valve diameter actually obtain in valves qualifying under it or that an equivalent discharge area be obtained by the use of larger valves, the rule would apply satisfactorily to that size of valve. However, the lowest lift valve actually has but ¼, the next larger less than ½ and the average lift of all but the highest lift valve, which average is .07 in., is but 56 per cent. of the lift assumed in the rule for these 4 in. valves.

MASSACHUSETTS RULE OF 1909.

$$A = (70\ W \div P) \times 11$$

A = area of safety valve in sq. in. per sq. ft. of grate.
W = lbs. of water evaporated per sq. ft. of grate surface per second.
P = boiler pressure (absolute).

This rule is merely the United States rule given above with a 3.2 per cent. larger constant and hence requiring a valve larger by that amount. The evaporation term is expressed in pounds per second instead of per hour and two constants are given in-

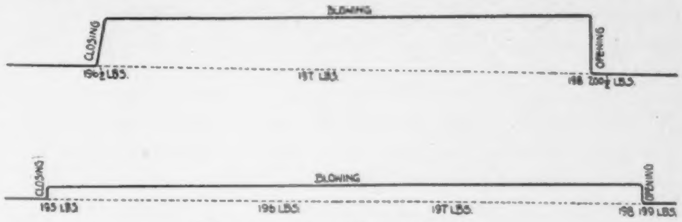


FIG. I.—VALVE LIFT DIAGRAM.

stead of one, but when reduced to the form of the United States rule it gives $A = .214 \times (W \div P)$. Figuring this back as was done above with the United States rule, shows that this rule assumes a valve lift of 1/33 of the valve diameter instead of 1/32. This changing of the assumed lift from 1/32 to 1/33 of the valve diameter being the only difference between the two rules, the inadequacy of the U. S. rule just referred to applies to this more recent rule of the Massachusetts Board.

PHILADELPHIA RULE.

$$A = 22.5\ G \div (P + 8.62)$$

A = total area of safety valve or valves in sq. in.
G = grate area in sq. ft.
P = Boiler pressure (gauge).

The Philadelphia rule now in use came from France in 1868, being the official rule there at that time and having been adopted and recommended to the City of Philadelphia by a specially appointed committee of the Franklin Institute. The area (A) of this rule is the effective valve opening, hence if it is applied as its derivation by the French requires, the lift of the valve must be known and considered. However, the example of its application given in a city ordinance, as well as that given in the original report of the Franklin Institute Committee, which recommended it, show the area (A) applied to the nominal valve opening. In the light of its derivation, this method of using it takes as the effective discharge area, the valve opening itself, the error of which is very great. Such use, as specifically stated in the report of the committee above referred to, assumes a valve lift at least ¼ of the valve diameter, *i. e.*, the practically impossible lift of 1 in. in a 4 in. valve.

The principal defect of these rules in the light of the preceding tests is that they assume that valves of the same nominal size have the same capacity and they rate them the same without distinction, in spite of the fact that in actual practice some have but ⅓ of the capacity of the others. There are other defects as

LOCOMOTIVE ARRANGED FOR TESTING SAFETY VALVES.

have been shown, such as varying the assumed lift with the valve diameter, while in reality with a given design the lifts are more nearly the same in the different sizes, not varying nearly as rapidly as the diameters. And further than this the actual lifts assumed for the larger valves are nearly double the actual average obtained in practice.

The direct conclusion in this is that existing rules and statutes are not safe to follow. Some of these rules in use were formu-

lated before, and have not been modified since spring safety valves were invented, and at a time when 120 lbs. was considered high pressure. None of these rules take account of the different lifts which exist in the different makes of valves of the same nominal size, and they thus rate exactly alike valves which actually vary in lift and relieving capacity over 300 per cent. It would, therefore, seem the duty of all who are responsible for steam installation and operation to no longer leave the determination of safety valve size and selection to such statutes as may happen to exist in their territory, but to investigate for themselves.

The elements of a better rule for determining safety valve size exist in Napier's formula for the flow of steam, combined with the actual discharge area of the valve as determined by its lift. In "Steam Boilers" by Peabody & Miller, this method of determining the discharge of a safety valve is used. The uncertainty of the coefficient flow, that is, of the constant to be used in Napier's formula when applied to the irregular steam discharge passages of safety valves has probably been largely responsible for the fact that this method of obtaining valve capacities has not been more generally used. To determine what this constant or coefficient of flow is and how it is affected by variations in valve design and adjustment, an extended series of tests were recently conducted by the writer at the Stirling Department of the Babcock & Wilcox Co., at Barberton, Ohio.

A 373 h. p. Class K, No. 20 Stirling boiler, fired with a Stirling chain grate, with a total grate area of 101 sq. ft. was used. This boiler contained a U type of superheater designed for a superheat of 50 degrees F. The water feed to this boiler was measured in calibrated tanks and pumped (steam for the pump being furnished from another boiler) through a pipe line all connections to which had been blanked by stop valves back of which there were open drips to insure that there was no leakage. The entire steam discharge from the boiler was through the valve being tested, all other steam connections from the boiler being either blanked or closed with stop valves beyond which were placed open drip connections to indicate any leakage. A constant watch was kept throughout the testing upon all points of the feed, and steam lines to insure that all water measured in the calibrated tanks was passing through the tested valves without intermediate loss.

The valves tested consisted of a 3 in., 3½ in. and a 4 in. iron stationary valve, and a 1½ in., 3 in. and 3½ in. locomotive valve, the latter with and without mufflers. These six valves were all previously tested and adjusted on steam. Without changing the position of the valve disc and ring the springs of these valves were then removed and solid spindles, threaded (with a 10 pitch thread) through the valve casing above, inserted. Upon the top end of these spindles, wheels graduated with 100 divisions were placed. Figure 3 shows the arrangement used with the locomotive valves, the spindle and graduated wheel being similar to that used with the stationary valves. By this means the valve lift to thousandths of an inch was definitely set for each test.

In conducting the tests three hours duration was selected as the minimum time for satisfactory results. Pressure and temperature readings were taken every three minutes, water readings every half hour. In all 29 tests were run, 15 were 3 hours long, 4 2½ hours, 3 2 hours and 7 of less duration.

Tests numbered 1 to 5 were preliminary runs of but one hour or less duration apiece, and the records of them are thus omitted in the table on the next page which gives lifts, discharge areas, average pressure and superheat, and the steam discharge in pounds per hour of each of the other tests. The discharge areas have been figured for 45 degree seats from the formula, $A = 2.22\ L\ D + 1.11\ L^2$, where A equals the effective area in sq. in., D equals the valve diameter in inches, and L equals the valve lift in inches. In tests 8 and 23 where the width of valve seat was .225 in. and .185 in., respectively, and the valve was thus slightly above the depth of the valve seat, the area was figured for this condition.

As previously stated the application of these results is in fixing a constant for the flow of Napier's formula as applied to safety valves. The formula is $W = AP \div 70$, in which W equals pounds of steam discharged per second, P equals the absolute steam pressure behind the orifice or under the valve and A equals the effective discharge opening in sq. in. This may be stated as $E = C \times A \times P$; in which E equals the pounds of steam discharged per hour and C equals a constant; the value of E, A and P being given for the tests, C is directly obtainable.

Figuring and plotting the values of this constant indicates the following conclusions:

(1) Increasing or altering the steam pressure from approximately 50 to 150 lbs. per sq. in. (tests 14 and 10) does not affect the constant, this merely checking the applicability of Napier's formula in that respect.

(2) Radically changing the shape of the valve disc outside of the seat at the huddling or throttling chamber, so-called, does

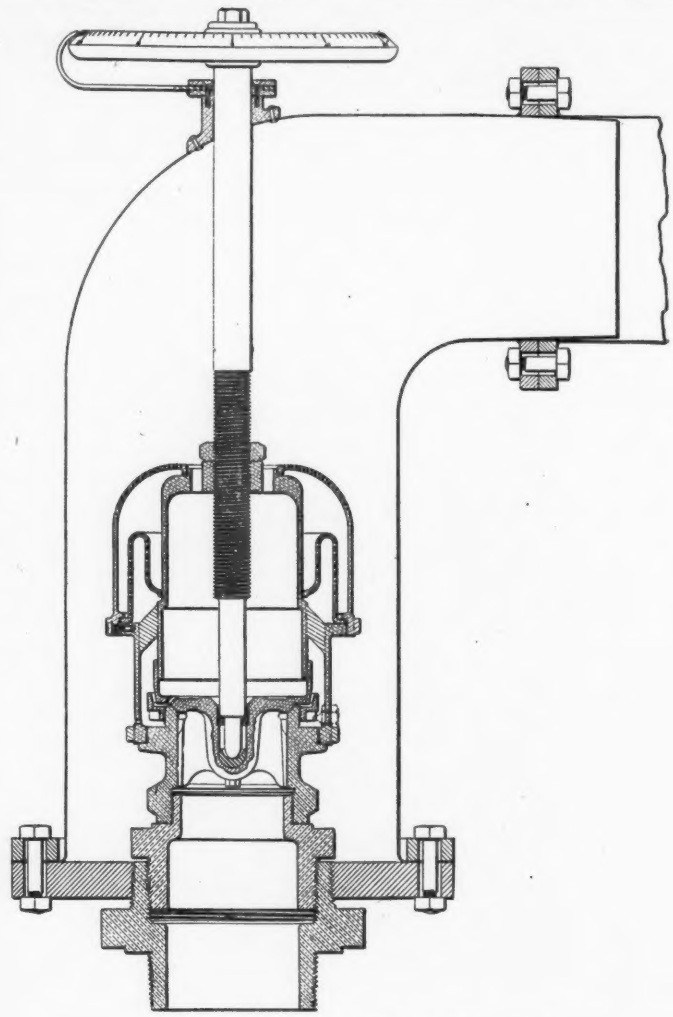


FIG. 3.—VALVE FITTED FOR CAPACITY TESTS.

not affect the constant or discharge. In test No. 15 the valve had a downward projecting lip, deflecting the steam flow through nearly 90 degrees, yet the discharge was practically the same as in tests Nos. 10 and 14, where the lip was cut entirely away, giving a comparatively unobstructed flow to the discharging steam.

(3) Moving the valve adjusting ring through much more than its complete adjustment range does not affect the constant or discharge (Tests Nos. 16 and 17).

(4) The addition of the muffler to a locomotive valve does not materially alter the constant or discharge. There is but 2 per cent. difference between tests Nos. 10 and 13.

(5) Disregarding the rather unsatisfactory 1½ in. and 3 in. locomotive valve tests, the different sizes of valves tested show a variation in the constant when plotted to given lifts of about 4 per cent.

(6) There is a slight uniform decrease of the constant when increasing the valve lifts.

The variations indicated in the last two conditions are not large enough, however, to materially impair the value of a single constant obtained by averaging the constants of all the 24 tests

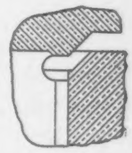
SAFETY VALVE CAPACITY TESTS.

Run at the Stirling Works of the Babcock & Wilcox Co., Barberton, Ohio. November 30 to December 23, 1908.

Test No.	Duration of test,	Size and type of valve	Adjustment remarks	Valve lift, in.	Pressure, lbs. per sq.in.	Superheat, deg. F.	Discharge Per hr., lbs. of steam.	Discharge Area,* sq.in.	Remarks.
6	3 hrs.	4-in. R.F. iron stationary.	Reglr. adj., exhaust piped.	0.0695	151.7	43.6	5,120	0.6226	No back pressure.
7	3 "	4-in. " " "	" " " "	.139	145.4	45.1	8,600	1.255	Back pressure 2 lbs.
8	3 "	4-in. " " "	" " " "	.180	135.7	49.2	11,020	1.704	Bk press. 3 lbs.; max. press.; lift greater than depth of seat.
9	3 "	4-in. " " "	" " " "	.1045	149.4	41.9	7,290	.9400	Back pressure, 1 lb.
10	2½"	3½ locomotive Form B.	" " without muffler.	.140	146.7	39.0	8,685	1.109	Tests 10 to 12 inclusive, with an open locomotive valve.
11	3 "	3½ " "	" " " "	.070	152.5	38.0	4,670	.5493	
12	3 "	3½ " "	" " " "	.105	150.3	41.2	6,780	.8280	
13	3 "	3½ " "	" " with muffler.	.1395	146.3	38.1	8,400	1.106	Muffler valve in this and following locomotive tests.
14	2 "	3½ " "	" " " "	.140	52.2	51.3	3,620	1.109	Test at low steam pressure.
15	2½"	Do.; with lipped feather.	" " " "	.140	146.4	39.0	8,600	1.109	Different type of valve disc.
16	3 "	4-in. R.F. iron stationary.	" " exhaust piped.	.140	138.5	42,3	8,770	1.265	No bk press.; rep. of test No. 7.
17	3 "	4-in. " " "	Adj. ring one turn 1-16 in. above regular position.	.140	142.0	50.1	8,900	1.265	Back press., 3 lbs.; ring position changed.
18	2 "	1½ locomotive Form B.	Reglr. adj. with muffler.	.107	140.8	23.0	2,515	.4272	Tests 18-21, inc., unsatisfactory; valve too small for boiler used.
19	1 "	1½ " "	" " " "	.060	151.2	None	1,550	.2038	
20	2½"	1½ " "	" " " "	.075	146.3	None	2,025	.2560	
21	2½"	1½ " "	" " " "	.075	147.7	None	1,975	.2560	
22	1½"	3½ R.F. iron stationary.	" " exhaust piped.	.070	146.8	42.6	4,320	.5493	No back pressure.
23	3 "	3½ " " "	" " " "	.140	139.9	43.6	8,360	1.136	No back press.; lift greater than depth of seat.
24	3 "	3½ " " "	" " " "	.105	141.6	48.7	6,300	.8280	Tests 24 to 27, inclusive, no back pressure.
25	3 "	3 " " "	" " " "	.130	140.1	48.4	6,370	.8846	
26	3 "	3 " " "	" " " "	.100	142.8	45.6	5,160	.6770	
27	2 "	3 " " "	" " " "	.070	142.4	29.5	3,705	.4716	
28	3 "	3 locomotive Form B.	" " with muffler.	.130	138.4	48.7	7,060	.8846	
29	3 "	3 " "	" " " "	.090	139.3	43.9	4,950	.6034	

*The valves all having 45 deg. bevel seats these areas are obtained from formula: $a = 2.22 \times D \times l + 1.11 \times l^2$; except where, as in test Nos. 8 and 23, the valve lift is greater than the depth of the valve seat, where the following formula is used: $a = 2.22 \times D \times d + 1.11 \times d^2 + \pi \times D \times (l - d)$.
a = discharge area (sq. in.). D = valve diameter (in.). l = valve lift (in.). d = depth of valve seat (in.).

NOTE.—The four wings of the valve feather or disc probably reduce the flow slightly, but as these are cut away at the seat (see sketch) a definite correction of the exit areas for them is impossible. Further, the formula constants are desired for the valves as made.



given. The selection of such a constant is obviously in accord with the other four conditions mentioned. This average constant is 47.5, giving the formula $E = 47.5 \times A \times P$. Its theoretical value for the standard orifice of Napier's formula is 51.4, of which the above is 92½ per cent.

To make this formula more generally serviceable, it should be expressed in terms of the valve diameter and lift, and can be still further simplified in its application by expressing the term E (steam discharged or boiler evaporation per hour) in terms of the boiler heating surface or grate area. For the almost universal 45 degrees seat the effective discharge area is, with a slight approximation ($L \times \sin 45° \times \pi \times D$), in which L equals the valve lift vertically in inches and D the valve diameter in inches. Substituting this in the above formula gives

$$E = 105 \times L \times D \times P.$$

Note that the nominal valve area does not enter into the use of this formula and that if a value of 12, for instance, is obtained for D it would call for 2, 6 in. or 3, 4 in. valves. For flat seats this constant becomes 149.

The fact that these tests were run with some superheat (an average of 37.2 degrees F.), while the majority of valves in use are used with saturated steam, would, if any material difference exists, place the above constants on the safe side.

To make the use of the rule more direct where the evaporation of the boiler is only indirectly known it may be expressed in terms of the boiler heating surface or grate area. This modification consists merely in substituting for the term E (pounds of total evaporation) a term H (sq. ft. of total heating surface) multiplied by the pounds of water per sq. ft. of heating surface which the boiler will evaporate. Evidently the value of these modified forms of the formula depends upon the proper selection of average boiler evaporation figures for different types of boilers and also upon the possibility of so grouping these boiler types that average figures can be thus selected. This modified form of the formula is $D = CH \div LP$, in which H equals the total boiler heating surface in sq. ft. and C equals a constant.

Values of the constant for different types of boilers and service have been selected. These constants are susceptible of course to endless discussion among manufacturers, and it is undoubtedly more satisfactory where any question arises, to use the form containing the term E itself. Nevertheless, the form containing the term H is more direct in its application and it is believed that the values given below for the constant will prove serviceable. In applying the formula in this form rather than the original one, containing the evaporation term E, it should be remembered that these constants are based upon average proportions and hence should not be used for boilers in which any abnormal proportions or relations between grate area, heating surface, etc., exists.

For cylindrical multitubular, vertical and water tube stationary boilers a constant of .068 is suggested. This is based upon an average evaporation of 3½ lbs. of water per sq. ft. of heating surface per hour, with an overload capacity of 100 per cent., giving 7 lbs. per sq. ft. of heating surface, the figure used in obtaining the above constant.

For water tube marine and Scotch marine boilers, the suggested constant is .095. This is based upon an overload or maximum evaporation of 10 lbs. of water per sq. ft. of heating surface per hour.

For locomotives the suggested constant is .055. In locomotive practice there are special conditions to be considered which separate it from regular stationary and marine work. In the first place the maximum evaporation of a locomotive is only possible with the maximum draft obtained when the cylinders are exhausting up the stack, at which time the throttle is necessarily open. The throttle being open is drawing some of the steam and therefore the safety valves on a locomotive can never receive the full maximum evaporation of the boiler. Just what per cent. of this maximum evaporation the valve must be able to relieve under the most severe conditions can only be determined experimentally. Evidently the most severe conditions obtain when an engineman after a long, hard, up-hill haul with a full glass of water and full pressure, reaching the top of the hill, suddenly shuts off his throttle and injectors. The work on the hill has set the engine steaming to its maximum and the sudden closing of throttle and injectors forces all the steam through the safety valves. Of course, the minute the throttle is closed the steaming quickly falls off and it is at just that moment that the most severe test upon the valves comes.

A large number of service tests have been conducted to determine this constant. The size valves upon a locomotive has been increased or decreased until one valve would just handle the maximum steam generation, and the locomotive heating surface being known, the formula was figured back to obtain the constant. Other special conditions were considered, such as the liability in locomotive practice to a not infrequent occurrence of the most severe conditions; the exceptionally severe service which locomotive safety valves receive; and the advisability on locomotives to provide a substantial excess valve capacity.

As to the method of applying the proposed safety valve capacity rule in practice, manufacturers could be asked to specify the

capacity of their valves, stamping it upon them as the opening and closing pressures are now done. This would necessitate no extra work further than the time required in the stamping, because for valves of the same size and design giving practically the same lift, this would have to be determined but once, which of itself is but a moment's work with a small portable lift gauge that is now manufactured. The specifying of safety valves by a designing engineer could then be as definite a problem as is that of other pieces of apparatus. Whatever views are held, as to the advantages of high or low lifts, there can be no question, it would seem, as to the advantage of knowing what this lift actually is, as would be shown in this specifying by manufacturers of the capacity of their valves. Further, as to the feasibility of adopting such a rule (which incorporates the valve lift) in statutes governing valve sizes:—this would involve the granting and obtaining by manufacturers of a legal rating for their valve designs based upon their demonstrated lifts.

BACK-GEARED CRANK SHAPERS.

A 21 in. back-geared crank shaper, one of a new line which is being placed on the market by The American Tool Works Company of Cincinnati, is illustrated herewith. To give some idea of the power and efficiency of these machines the results of several tests are shown in the tables. These are not intended to represent the maximum capacity of the machines, but leave a good factor of safety and are well within their limits. The 21 in. machine has a 21½ in. stroke, a down feed to the head of 9 in. and a table travel of 14½ vertically and 26½ in. horizontally. The column is usually deep and wide, tapering slightly towards the top. It is strongly braced internally, and is reinforced outside by a wide, deep rib. An exceptionally long bearing is provided for the ram. The base is deep and strongly ribbed, and is of pan construction to catch oil drippings. The ram is heavy and designed for uniform rigidity throughout the entire length of stroke. It is well braced by internal ribs, and has long wide bearings on the column with a continuous taper gib, having end screw adjustment for taking up the wear. The stroke of the ram is positive and has eight changes, ranging from 7.7 to 96 strokes per minute. The length of stroke may be easily changed without stopping the machine. The device for positioning the stroke is located on the ram near the head and may be operated while the machine is running. A pointer on the ram, traveling along an index, shows the length of stroke as set. The rocker arm is extra heavy and thoroughly braced and gives practically a uniform rate of speed to the ram for its entire stroke; it also provides an exceedingly quick return. The machine is readily changed from single to back-geared through a convenient, self-locking lever, and has a back-gear ratio of 24.3 to 1, which with the large cone pulley, gives it extraordinary power for taking heavy cuts.

The head is operative at any angle within an arc of 100 degrees and has a convenient and efficient locking device. The down

TEST SHEET OF 21" BACK GEARED SHAPER.

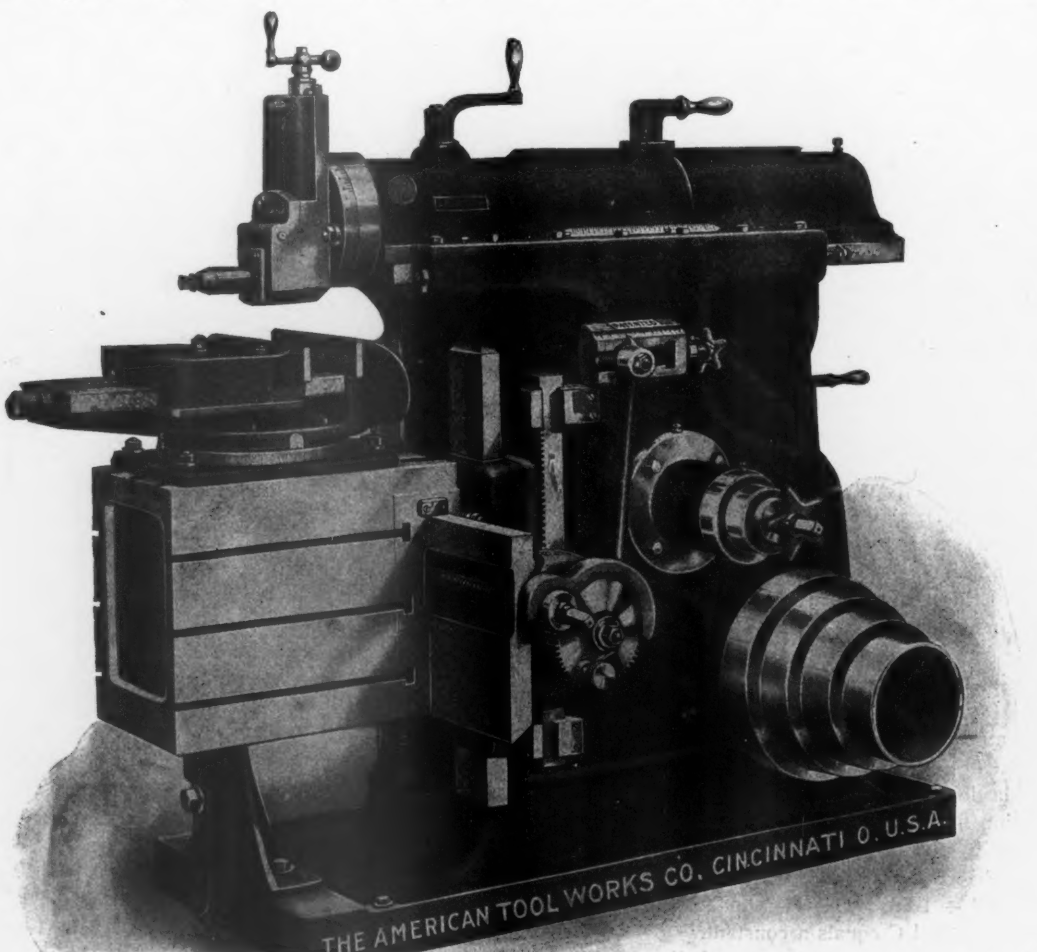
Depth of cut.	Feed per Stroke.	Cutting Speed Ft. per Min.	Belt on Cone Step.*	Back Gear Position.	Revol's of Cone.	Length of Cut.	Amperes at Tool.	H. P. at Tool.	Voltage.
½"	.080"	11.4	2	In	157	13½"	9	2.65	220
⅝"	.160"	16.3	3	In	225	13½"	24	7.07	do.
⅝"	.200"	11.4	2	In	157	13½"	21	6.19	do.

Above Test Made in Cast Iron—Close Grained—18" Stroke.

Depth of cut.	Feed per Stroke.	Cutting Speed Ft. per Min.	Belt on Cone Step.*	Back Gear Position.	Revol's of Cone.	Length of Cut.	Amperes at Tool.	H. P. at Tool.	Voltage.
½"	.080"	11.4	2	In	157	14"	21	6.19	220
½"	.096"	11.4	2	In	157	14"	24	7.07	do.
⅝"	.080"	11.4	2	In	157	14"	32	9.43	do.

Above Test Made in Machinery Steel—Very Tough—21" Stroke.

*Cone steps are numbered from 1 to 4, 1 being the largest diameter.



TWENTY-ONE INCH BACK GEARED CRANK SHAPFR.

slide is fitted with a continuous taper gib having end screw adjustment, for taking up the wear. The down feed is of unusual length and the feed screw has an adjustable graduated collar reading to .001 in. The table is of box form with three T-slots on both the top and the sides. It is thoroughly braced internally, insuring accuracy and stiffness and is readily detachable. The apron is provided with a continuous taper gib having end screw adjustment. It has three T-slots on the face for clamping work when the table is removed. A patented automatic stop releases the feed and prevents breakage to parts when the tool is fed into the cut or should the apron be accidentally fed to its limit in either direction on the rail.

The cross rail is of box form, heavy and strongly ribbed. It is of exceptional length, giving the table a long horizontal range of travel. It is bolted to the column by clamps and bolts of improved design, which prevent the cross rail from dropping away when the binder bolts are loosened. A telescopic elevating screw of large diameter is provided, having a ball-bearing thrust. The cross feed is a new patented design. It is variable and automatic with a range of .008 in. to .200 in., instantly obtainable while the machine is running. It is supplied with graduations either side of zero and a pointer reading from 1 to 25 notches, each notch representing .008 in. feed. The construction is such as to render unnecessary any adjustment of the feeding mechanism due to change of the position of the rail. The feed is uniform as set, regardless of the position of the rail. The feed is thrown in or out, and also reversed through the knob on the large feed gear. The feed gears are neatly covered to afford protection.

The rocker arm is made of double section at the top and this with the large opening through the column permits a shaft 3½ in. in diameter to be passed under the ram for keyseating. Larger shafts may be keyseated by setting over the table to allow the shaft to pass outside of the column, using the head set at an angle. Special attention has been paid to the thorough lubrication of all working parts. The ram slides are oiled from the center where oil pockets are provided, from which felt wipers take their supply of oil and distribute it through oil grooves to the extreme ends of the slides, thus doing away with a multiplicity of oil holes to be attended to. These slides are provided with felt wipers at both the front and center of the column. An oil pocket is cast integral with the column at the rear, storing any waste of oil, which may be drawn off through a pipe extending from the rear of column. A large quantity of oil is stored in a pocket cast integral with the arm, which, with suitable means of distribution, insures thorough lubrication on the crank pin and the sliding block in the rocker arm.

This new line of shapers consists of a 15 in. single-geared and 16, 18, 21, 25 and 30 in. back-geared machines. If desired they may be furnished with four-speed gear boxes and electric motor drives.

TEST SHEET OF 16″ BACK GEARED SHAPER.

Depth of cut.	Feed per Stroke.	Cutting Speed Ft. per Min.	Belt on Cone Step.*	Back Gear Position.	Revol's of Cone.	Length of Cut.	Amperes at Tool.	H. P. at Tool.	Voltage.
¼″	.160″	17.3	2	In	210	12⅛″	21	6.3	224
⅜″	.088″	17.3	2	In	do.	do.	24	7.2	do.
½″	.080″	17.3	2	In	do.	do.	23	6.9	do.
Above Tests Made in Cast Iron—Close Grained—16″ Stroke.									
⅛	.080	17.3	2	In	210	12″	11	3.3	224
¼	.024	9.9	4	In	418	do.	15	4.5	do.
¼	.040	14.	3	In	294	do.	15	4.5	do.
Above Tests Made in Machinery Steel—Very Tough—16″ Stroke.									

*Cone steps are numbered from 1 to 4, 1 being the largest diameter.

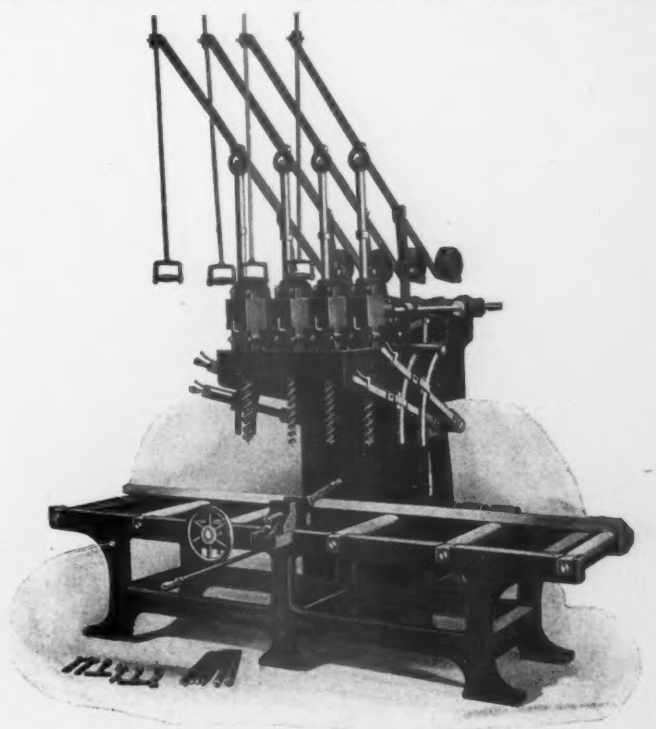
Safety Appliance Hearing.—The Interstate Commerce Commission will hold a hearing on May 5 in Washington, D. C., concerning an increase in the minimum percentage of power brakes on railroad trains.

FIVE-SPINDLE VERTICAL CAR BORING MACHINE.

The Hamilton five-spindle, vertical car boring machine, shown in the illustration, is designed for heavy boring in railroad and car shops and is manufactured by The Bentel-Margedant Company, Hamilton, Ohio. The illustration shows three vertical and two radial spindles, but these are subject to variation in number.

The spindles, of heavy construction, are mounted in large housings which slide on the frame in improved dovetail slides. They have a 20 in. vertical stroke and a transverse adjustment of 22 in., the latter by means of a hand wheel and pinion with chain feed, quick and positive in action. Each spindle is separately driven by its own belt from the rear of the machine and any spindle may be thrown out of commission without disturbing the others. The spindles are provided with a miter gear drive which is covered by a dust-proof box; gears run in long slides preventing wear of the boxes by the action of the spindles. The spindles are brought down separately by hand to do the boring and are returned to their positions by counterbalanced levers in the three vertical spindles and by springs in the radials. Stop gauges are provided to gauge the depth of the hole.

The table is 10 ft. long, clamps 22 in. wide by 16 in. thick and has all the conveniences for handling heavy or light material. The top is provided with six rolls upon which the material rests. The center and two end rolls are geared together by a chain and may be driven either by power or hand feed. A large hand wheel is provided on the center roll for hand adjustment. A center clamp is also used to hold the material against the fence and to prevent the bits from raising it from the table. The power feed for the table consists of reversible friction pulleys controlled from the front by a convenient hand lever. The power feed is generally used for moving long distances, while the hand wheel feed is for accurate setting and short distances. A longer traveling table may be provided, if desired. The countershaft is placed on the floor at the rear of the machine and is provided with tight and loose pulleys. The machine weighs 7,000 lbs., occupies a floor space 6 by 10 ft. and requires from 10 to 15 h. p. for driving.



FIVE-SPINDLE VERTICAL CAR BORING MACHINE.

Address by F. W. Taylor.—Dr. Frederick W. Taylor, past-president of the American Society of Mechanical Engineers, gave an address before the College of Engineering of the University of Illinois on Thursday, February 18. His talk was along general engineering lines supplemented by anecdotes from the early part of the careers of successful engineers.

HIGH POWER MILLING MACHINES.

A few years ago railroad officials, in buying machine tools, were inclined to lay considerable stress upon the weight of the tool as an indication of its capacity. To-day the purchaser insists on having accurate information as to the quality and quantity of work which a tool is capable of turning out, and the weight is a matter of secondary importance. This, and the demand for high power machines, has lead the Cincinnati Milling Machine Company to design its latest line of milling machines on the basis of certain standard cuts which may be taken continuously on each size of machine. Starting with this as a basis, and with the results of elaborate tests and experiments to guide them, it has been possible to design each individual part to produce a most efficient and harmonious design as a whole. The value of high cutting capacity may be largely offset by inconvenience in operating the machine and this point has also been given careful consideration.

An important feature, especially from the manufacturing standpoint, is that the vertical and horizontal machines are identical up to the frame head, the vertical machine differing only in the frame casting, the mechanism at its top and the pair of bevel gears for changing the motion to the vertical shaft. An even more important feature, from the standpoint of the purchaser, is that the method of driving and feeding may readily be changed at any time to suit changes in his power transmission system. For instance, the constant speed standard belt-driven machine, with the driving shaft parallel to the spindle, may be changed to a right angle drive by simply changing the brackets. By substituting a simpler driving gear box a cone pulley drive may be used. In the former case the feed box is driven from the constant speed driving shaft and in the latter from the spindle, but with no change in the feed box itself. By changing brackets the cone pulley drive may be changed to one at right angles. By substituting a sprocket wheel for the driving pulley and adding a bracket at the base a constant speed motor may be applied. In the same way the cone pulley drive may be changed to a variable speed motor drive. By changing an index plate the feed on the constant speed drive machines may be changed from inches per minute to thousandths per revolution.

To give some idea of the power and efficiency of these machines a view of the No. 4 plain horizontal machine is shown in Fig. 1, milling four drop-forged steel pieces at one time, taking a cut 13/16 in. wide and 1¼ in. deep, at a table travel of 2 in. per minute. This amounts to 8⅛ cu. in. removed per minute. The machine is driven by a 10 h. p. motor.

The high power vertical machine, shown in Fig. 6, is engaged in milling forged steel bars, having 55,000 lbs. tensile strength and 50 per cent. elongation. The bars are 5 in. wide and the machine is taking a cut ⅛ in. deep and feeding at the rate of 16 in. per minute. This amounts to 10 cu. in. per minute. The 10 h. p. driving motor is slightly overloaded, delivering 12 gross horse power.

The constant speed belt-driven machine has sixteen changes in spindle speed. A clutch, operated by the lever at the right of the driving gear box, Figs. 2 and 3, allows the driving pulley to run loose on the shaft when the machine is not in operation. Fig. 3 is a view of the exterior of the driving gear box; Fig. 4 shows the interior. The upper part of the column, with the cover plate removed, on the opposite side of the machine from the gear box, is shown in Fig. 5. The tumbling gears, shown near the center of the box, in Fig. 4.

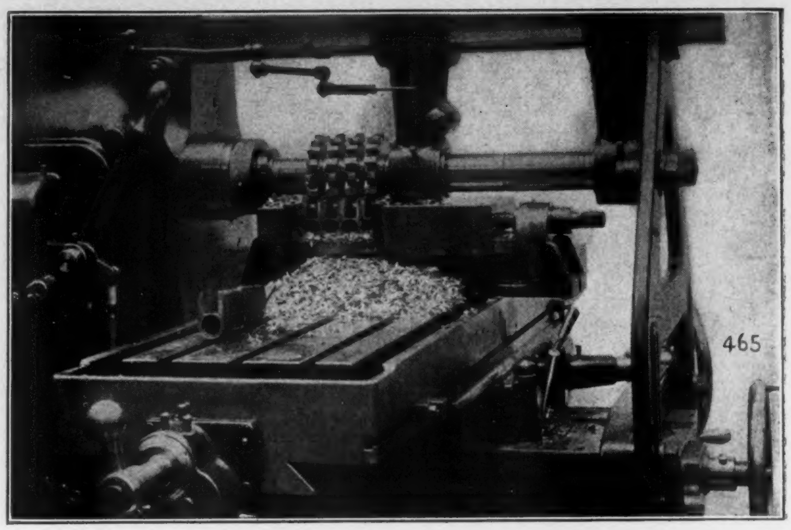


FIG. 1.—PLAIN HORIZONTAL MILLING MACHINE REMOVING 8⅛ CUBIC INCHES OF DROP-FORGED STEEL PER MINUTE.

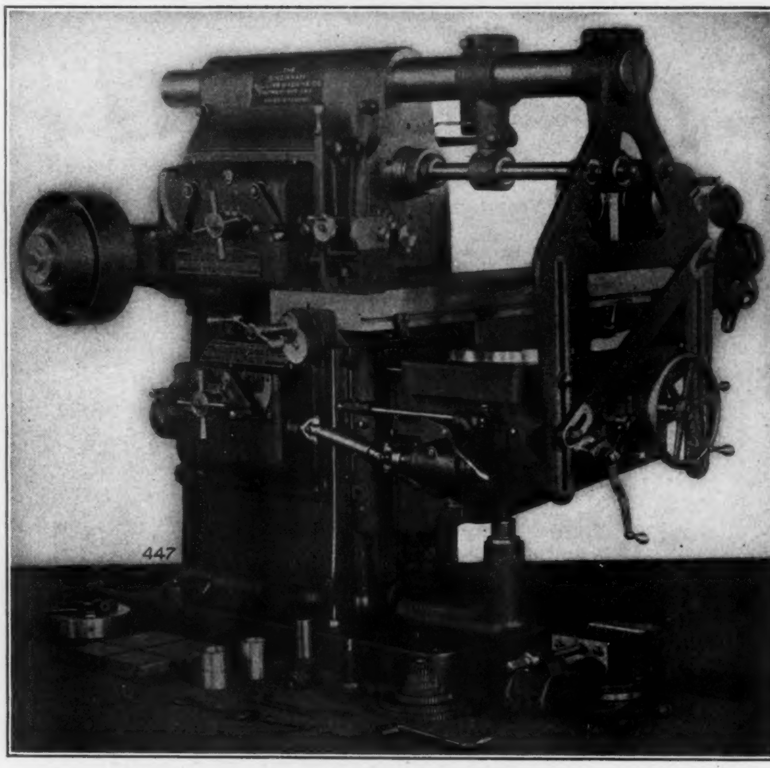


FIG. 2.—PLAIN HORIZONTAL MILLING MACHINE WITH RIGHT-ANGLE DRIVE.

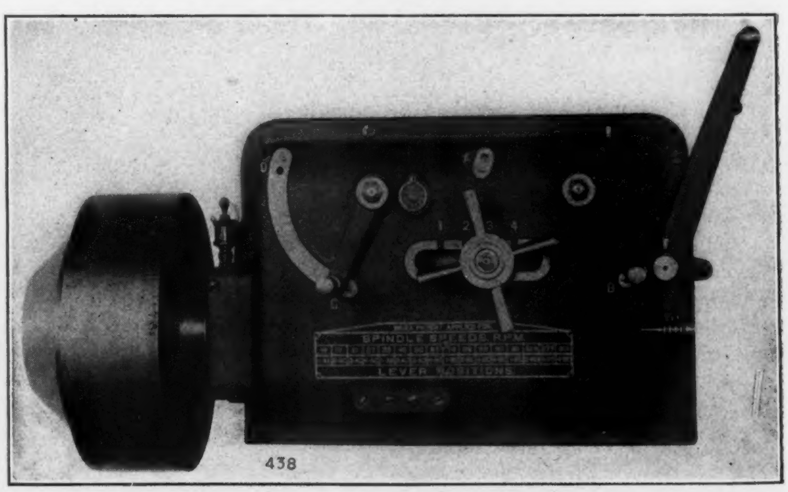


FIG. 3.—OUTSIDE OF DRIVING-GEAR BOX.

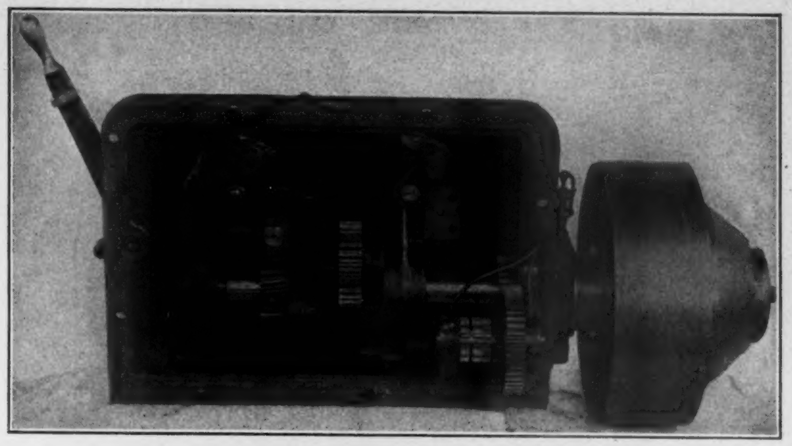


FIG. 4.—DRIVING-GEAR BOX, INSIDE.

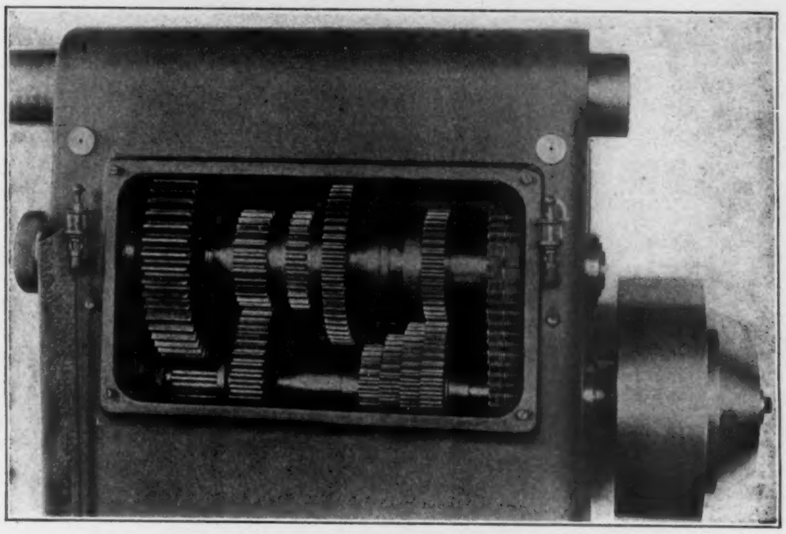


FIG. 5.—UPPER PART OF COLUMN WITH COVER-PLATE REMOVED SHOWING DRIVING-GEAR TRAIN.

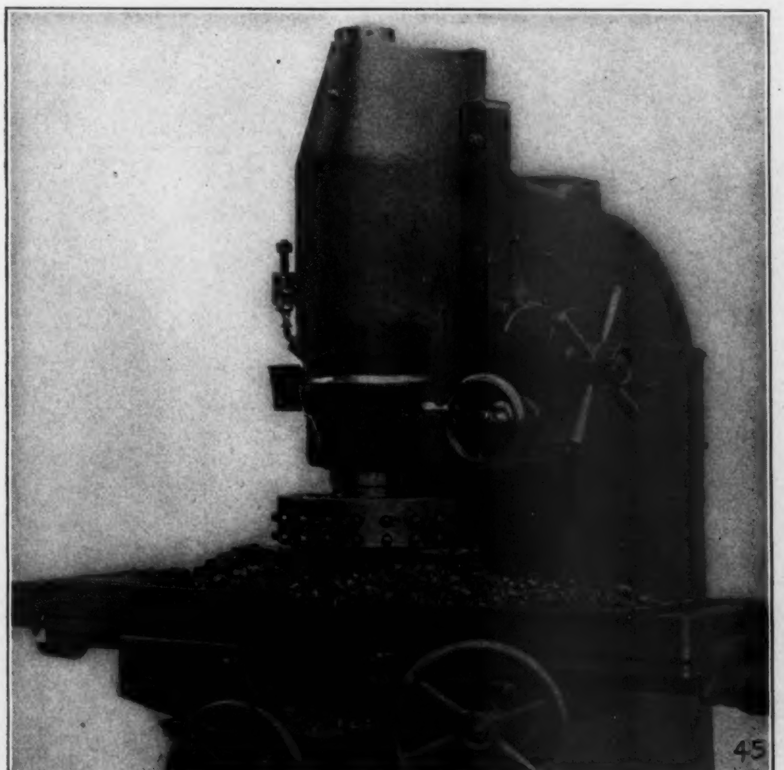


FIG. 6.—HIGH POWER VERTICAL MILLING MACHINE, REMOVING 10 CUBIC INCHES OF MATERIAL PER MINUTE FROM FORCED STEEL BARS. CUT 1/8 IN. DEEP AND 5 IN. WIDE. FEED 16 IN. PER MINUTE.

mesh with one of the four gears on the sleeve to the right on the lower shaft in Fig. 5. These four speeds are doubled by using the back gears at the left in Fig. 5. If the smaller one of the set of four gears is engaged with the large gear to the left on the sleeve on the spindle, eight additional spindle speeds may be obtained with the use of the back gears. The advantages of this scheme of transmission are that the spindle is relieved of torsional strains throughout its length and no gears are ever in mesh except those used for transmission. The eight fastest spindle speeds are obtained with only two pairs of gears in mesh.

The sliding gears are operated by the lever which takes the positions C and D in Fig. 3; the back gears and clutch pinion are moved by the lever which takes the positions A and B. The narrow gear to the right of the back gears in Fig. 5 facilitates the engagement of the teeth in the back gears. The tumbler is operated by the pilot wheel on the gear box and is automatically and positively locked in position after each change in speed. The tumbler gear mechanism is illustrated in Fig. 7. The arrangement of the index plate is clear from the illustrations. In case the gears should interfere while being shifted they may be revolved slightly by a gentle pressure on the treadle, which is connected to the main starting lever. When a cone pulley drive is used the tumbler mechanism and two of the cone gears are done away with.

By pulling out the pin, in the frame near the upper right hand corner of the driving gear box, the ribs in the face-gear web are engaged by a locking pin and the spindle is locked, a desirable feature when attaching or removing arbors, or face mills which screw on the spindle. The pin is automatically released when the starting lever is thrown to the left.

The feed box is just below the driving gear box, and provides 16 feeds; it is quite similar to the driving gear box in principle, except that the tumbling shaft is the last instead of the first shaft, thus making it possible to use gears of large diameter running at moderate circumferential speeds. The feed may be changed while the machine is in operation. The interior of the feed tripping and reversing box is shown in Fig. 8. This is located on the side of the knee and is connected to the feed box by the universal joint shaft. The feed trip mechanism, of the single plunger type, operates through a large clutch on a shaft in the reverse box, which runs ten times as fast as the feed screw. The strain on the teeth is therefore much lower and it is very sensitive. The feed screws are of large diameter with double threads and steep pitch and are provided with ball bearing thrust bearings. The table is provided with a quick return handwheel.

The column and knee are both of box construction, heavy and rigid. The table is of unusual depth with large bearings; wear is in all cases taken up by adjustable gibs. The outer arbor bearing is rigidly supported. Special attention has been given to the lubrication. A circular milling attachment has been made to fit both the horizontal and vertical machines.

The vertical type machines differ from the horizontal type only as concerns the distinctly vertical features. They are designed for heavy duty, and the parts are of the largest proportions practicable. The spindle is driven from the horizontal driving shaft by miter gears of large diameter and coarse pitch. The gear on the spindle is located so as to bring the drive as close to the lower bearing as possible, thus reducing the liability of torsional vibration to a minimum.

The head frame has long bearing surfaces and there is provision for taking up wear by means of a taper gib. There is also an adjustment provided for maintaining the vertical alignment of the spindle. When

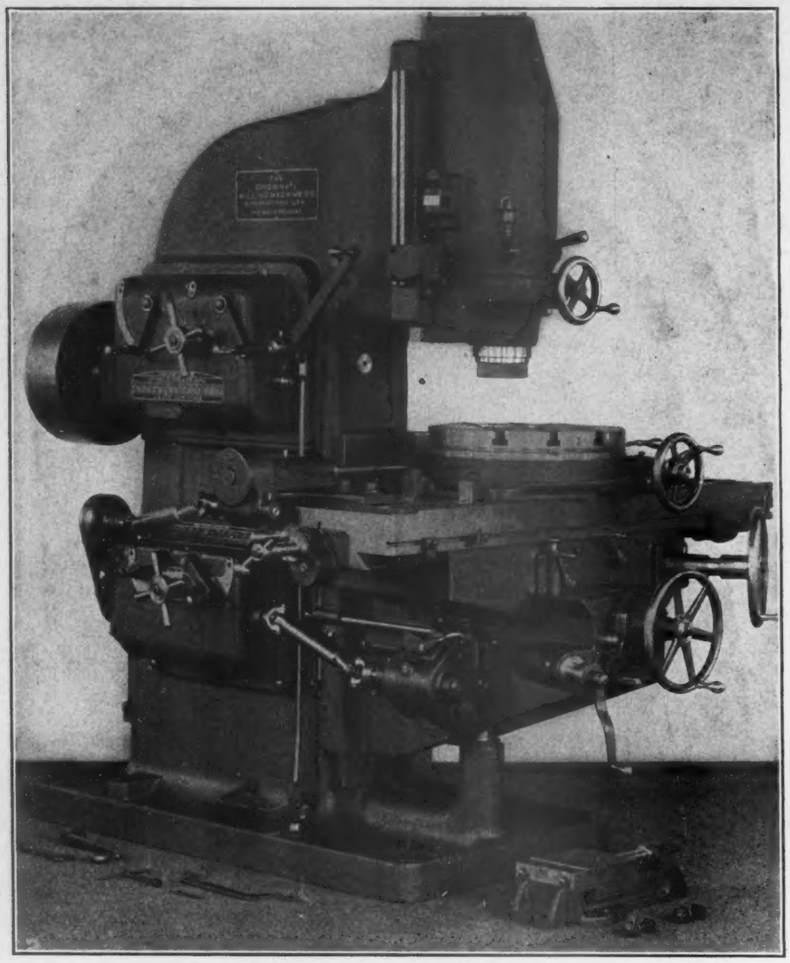


FIG. 9.—VERTICAL MILLING MACHINE, CONSTANT SPEED BELT DRIVE, CIRCULAR MILLING ATTACHMENT.

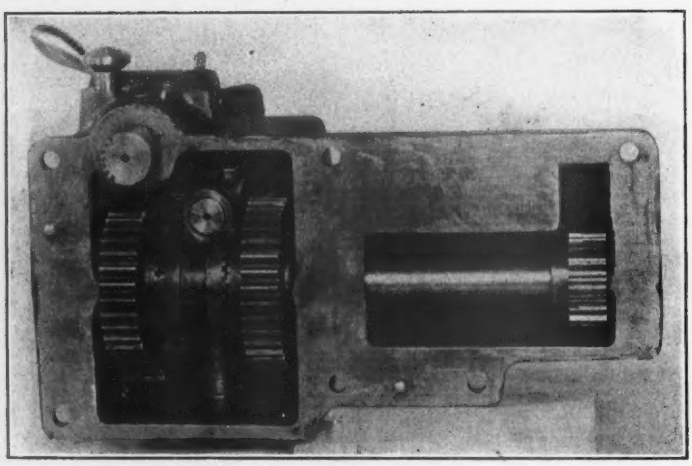


FIG. 8.—INSIDE OF FEED TRIPPING AND REVERSING BOX.

the machine is used on repetition work, requiring heavy cutting, the gib screws may be tightened so as to securely clamp the head to the body of the machine and thus hold it in a fixed position. The spindle may be adjusted vertically by means of the mechanism at the side of the head. The spindle has the same size bearings and is of the same length as that on the horizontal machines of equivalent size.

There is a pilot wheel for quick adjustment at the rate of 6 inches per turn. There is also a slow hand movement which is brought into engagement by means of a positive clutch operated by the knob on the end of the pilot wheel shaft. The slow movement is provided with a micrometer dial. The hand stop at the side of the head is fitted with a micrometer adjustment.

A COMPRESSED AIR TRACTION SYSTEM.

The buildings of the Plymouth Cordage Co., Plymouth, Mass., on account of their extent—a length of 2,500 feet and breadth of 1,000 feet—can only be served to advantage with some sort of surface track scheme. This service is attained by compressed air locomotives, hauling small flat cars on a narrow gauge track. Five locomotives are in use. They have 5 x 10 inch cylinders, two coupled 24 inch drivers, a single storage tank 4 x 11 feet, with a capacity of 132 cubic feet, and weigh 8,500 pounds each. The track is run about the yard, into or through buildings, many of which are filled with inflammable material, with no danger from fire. A consideration of this single feature has convinced the owners that the steam locomotive is barred and the electric motor has a serious handicap in comparison.

The locomotives are charged at various points about the plant. The charging valves are located particularly with the idea of having the tanks filled at the same time that the cars are being loaded or unloaded. Some of the runs are quite long, the longest being 2,400 feet and the round trip under favorable weather conditions is made with one charge. On this run a net load of 8,500 pounds is carried and the cost of air figures .04 of a cent per ton per 100 feet. Other runs figure .08 of a cent per ton per 100 feet.

This cost is based on a cost of one-half cent per 100 cubic feet of free air and includes all charges up to delivering the air into the mains at 200 lbs. pressure; these figures are on the conservative side.

The system as a whole, taking lump figures, moves one ton, net load, one hundred feet for approximately one cent. This includes the air used for all other purposes, fixed charges on all the rolling equipment as well as compressing apparatus, and all attendance.

Large Cantilever Bridge Opened.—The Queensboro bridge between Manhattan and Queens boroughs, passing over Blackwells Island, New York, was opened on March 30. This bridge cost $20,000,000 and has a total length of 7,636 ft.

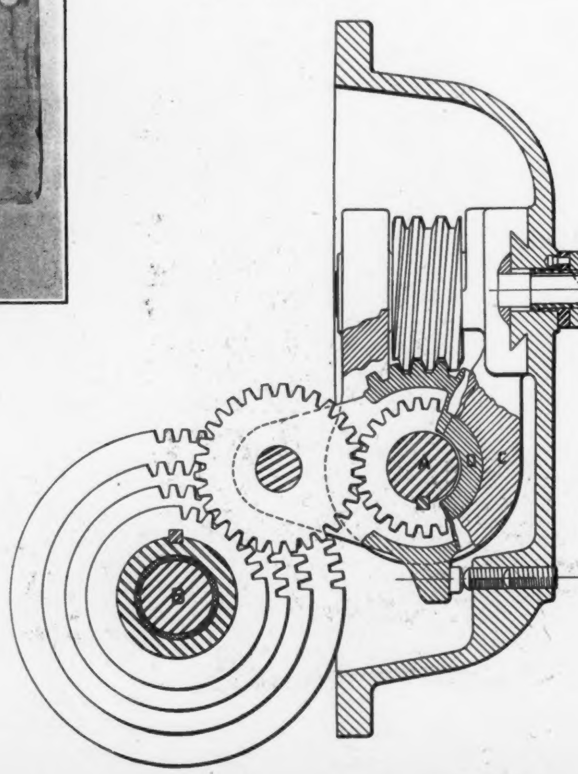
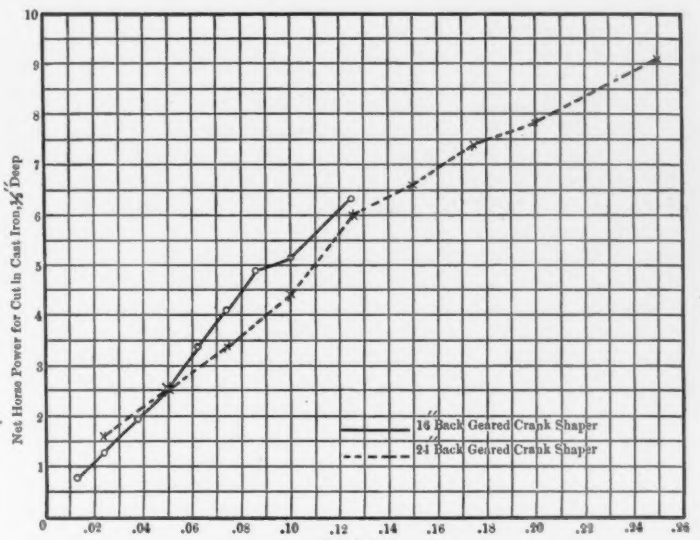


FIG. 7.—TUMBLER GEARS AND FRAME.

SHAPER TESTS.

Several tests were recently made by the Queen City Machine Tool Company of Cincinnati to determine the horse power required by shapers under conditions met with in ordinary practice. These were made on a 16 in. shaper, driven by a 5 h. p. constant speed motor, and a 24 in. shaper, driven by a 20 h. p. motor. In both cases the shapers were belt-driven from a countershaft which was driven by an electric motor. The length of stroke in each case was 16 in., being the rated capacity of the smaller machine. All cuts were made with the back-gears engaged. The 16-in. machine was run at an average cutting speed of 24 ft. per minute, and the 24-in. at 22 ft. per minute.

The motor and countershaft were first run idle and the power noted. In the values noted on the diagram this is deducted from the other readings, the object of the test being to learn the horse power required to run the machine idle, and when cutting. The motor was arranged to take care of its own loss, and this would perhaps vary some in different types. When the machine belt was thrown in there was no appreciable increase in the current taken for the 16-in. shaper, and there was only about ½ ampere rise at the moment of reverse. The 24-in. shaper took just ½



TESTS OF 16 AND 24 IN. BACK GEARED CRANK SHAPERS.

ampere to run the ram on the stroke, and nearly 2 amperes at the moment of reverse. All readings were taken at the highest point reached by the needle of the ammeter on each stroke. The cuts were all ½ in. deep; the material was cast iron of a rather hard grade. The first cut on each machine was with a one notch feed, and each succeeding one with a one notch increase of feed, except the last one in each test.

It will be seen that the horse power on a given cut was about the same with both machines, and that it increased by about equal amounts for each increase in feed, showing little loss from bind and friction, even under the heavier cuts. This is accredited to accurate fitting of the machine parts, and is something of an achievement when the overhang and twist inherent in a shaper are considered.

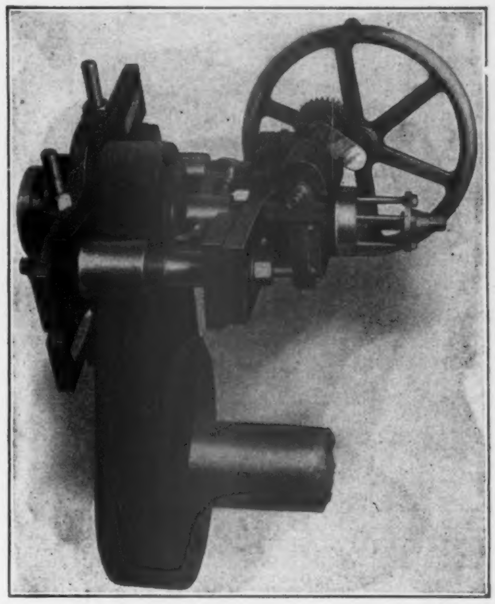
In selecting a motor for a shaper it is important to note that the return stroke of the ram is an idle one, consequently a motor, if of standard make, can be used with a rating somewhat less than the horse power called for, as such motors provide for a momentary overload of 100 per cent.

ELECTRIC HAMMER.—An electric hammer, which has been used very successfully for chipping steel plates and iron castings, has been developed by The Cincinnati Electrical Tool Company, Cincinnati, Ohio, and will shortly be placed on the market. The hammer is light and its action under severe service conditions seems to indicate that it will not only prove successful but can be maintained at a very low cost, both as concerns power consumed and repairs required.

UNIVERSAL BORING, TURNING AND FACING MACHINE.

The tool shown in the illustration was originally designed for turning off the rivet head on crank pins, in order to remove them; it is, however, adapted for a variety of other work. Two bars, with Vs cut in them, fit over the crank pin and are drawn together by the two one-inch bolts, clamping the pin firmly. The body of the machine is attached to this base by bolts which pass through the two adjustable spacing blocks that straddle the crank.

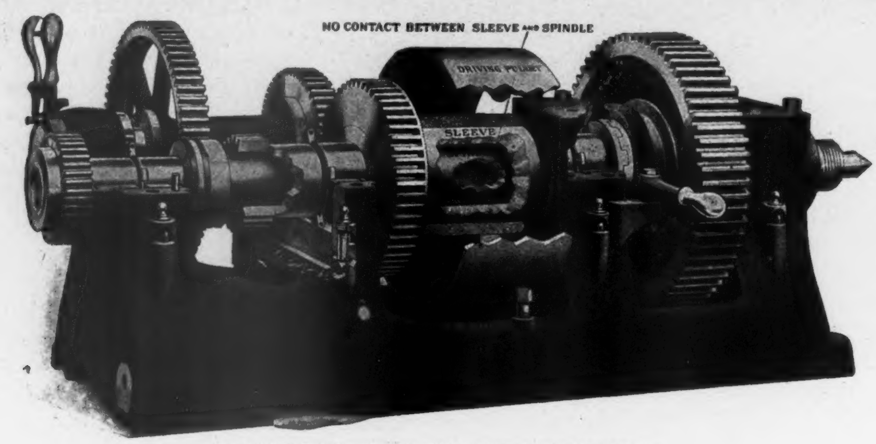
The spindle is driven by the handwheel through the two spur gears and a worm and worm wheel. The handwheel may be replaced by a pulley, electric motor or air drill. Three spindle speeds are available by interchanging the spur gears or by driving direct without these gears. The spindle has an endwise movement of 4 in. and will face up to about 12 in. in diameter. The cutting tool fits in a steel slide in the end of the spindle and is adjustable for different diameters by means of a hand feed screw at the end of the slide. The spindle is fed endwise by the screw with a square head at the extreme right.



BORING, TURNING AND FACING MACHINE.

The device when clamped in position is firm and rigid, yet each piece is light enough to be easily handled by one man in setting the machine up. It is claimed that at least 70 per cent. of the time required for chipping off the crank pin rivet head with a hammer and chisel may be saved by the use of this device. By using an extra facing attachment it is possible to face off pump or engine valve seats, it being immaterial whether the steam chest is solid or whether the valve seat is several inches below the face of the chest. When used on work of this kind the feed is operated by a star wheel knocker. For turning, an offset tool is used and it is possible, of course, to turn for comparatively small lengths only. This machine is made by H. B. Underwood & Co., of Philadelphia.

PAINTING STEEL PASSENGER CARS.—After building a coach entirely of steel at great expense so as to safeguard the passenger against fire, the builder is often required to paint and varnish the exterior and grain the interior to resemble wood, using highly inflammable material. This is, of course, an inheritance from the wooden coach, a habit which is hard to change. Steel can be given an excellent dull paint finish which could be easily kept clean and we await some Lochinvar to lead us away from the highly polished and inflammable finish now in vogue. Incidentally the subject of noise due to the use of steel was a mooted question before any coaches were built, but anyone who has ridden in a steel coach will concede that, except for a slight drumming sound over the trucks, there is, if anything, less noise in a steel than in a wooden coach.—*John McE. Ames before the Central Railway Club.*

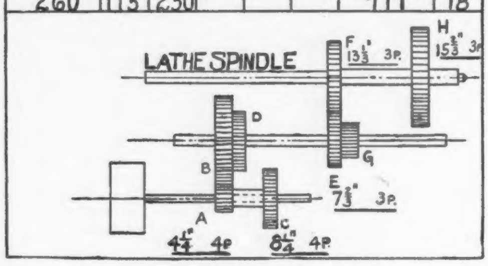


ARRANGEMENT OF PATENT LATHE HEADSTOCK.

MODERN HEAVY DUTY LATHE HEADSTOCKS.

The following data, furnished by The Lodge & Shipley Machine Tool Company, Cincinnati, Ohio, presents a comparison of their patent head lathe with the all-geared lathe headstock. The all-geared head recognizes the necessity of accumulating belt travel, at the expense of spindle speed. Its power possibilities are very great, but power is obtained at the expense of the open belt speeds. The arrangement of an all-geared head is shown on one of the accompanying diagrams. The compact and powerful design is evident and the broad face and coarse pitch gearing will transmit much power. Both the all-geared head and the Lodge & Shipley patent head are capable of driving high speed steels beyond the limit of their efficiency. There are three

SPINDLE SPEEDS ALL OBTAINED THROUGH GEARS	SURFACE SPEED ON WORK IN FEET PER. MINUTE					PERIPHERY SPEED ON GEARING	H.P. OF DRIVING BELT
	2"	4"	6"	8"	20"		
28	15	29	44	59	148	112	12
35	18	37	55	73	180	140	15
44	23	46	69	92	230	176	18
51	27	53	80	106	260	179	12
62	32	65	97	130		217	15
77	40	81	121	161		270	18
93	49	97	145	195		376	12
114	60	119	179	239		457	15
141	74	148	221	296		494	18
172	90	180	270			680	12
210	110	120				750	15
260	115	230				911	18



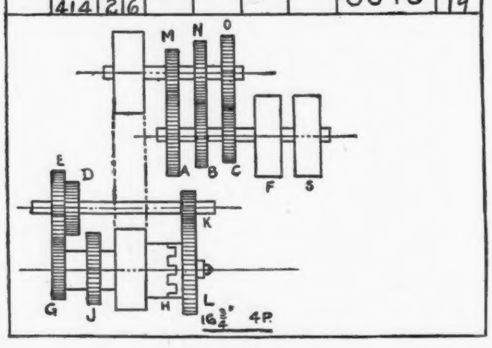
ALL-GEARED HEAD LATHE.

serious defects in the all-geared head design: No open belt cuts; no adjustment for wear of headstock gearing; high gear speed of headstock gearing when lathe is run on small diameters.

No open belt cuts are possible because a gear ratio must exist between the driving pulley and the spindle, the object being to make use of the high belt speed, and consequent great power obtained by revolving the headstock pulley at a speed far greater than would be practicable if carried upon the lathe spindle. The coarse pitch, wide face gearing is of such design as to transmit great power from the fast running driving belt to the spindle. This coarse pitch gearing is bound to mark the work being turned, particularly upon finishing cuts. This marking will be the same as that seen on work when the finishing cut is taken with worn back gears on a cone-head lathe. Finer pitch gears in the headstock will tend to remedy this fault, but with the sudden heavy loads that are thrown upon the gearing when picking up high speed cuts, the life of the gearing will be short.

No adjustment for gear wear. Since the shafts of the all-geared head are carried in bearings that are in alignment with each other, having no adjustment for wear, the wear of the gearing, that is inevitable from a constant service, will make the drive become noisy in operation. Just how long it will be before this becomes so great as to seriously endanger the quality of the machine output will depend upon the character of the service demanded from the lathe. The all-geared headstock illustrated, driven by a 15 h.p. motor, became so noisy after being less than four years in operation that it is was necessary to take out the machine and substitute a patent head. The work was limited to steel bars of 5½ in. diameter, one roughing and one finishing cut being taken; the bar was then finished to size on a grinder. The use of rawhide in place of the iron or steel pinions will remedy the noisy operation of the headstock, but will prove quite an expense to maintain, since the life of a rawhide pinion was found to be hardly two years, in the all-geared headstock under consideration.

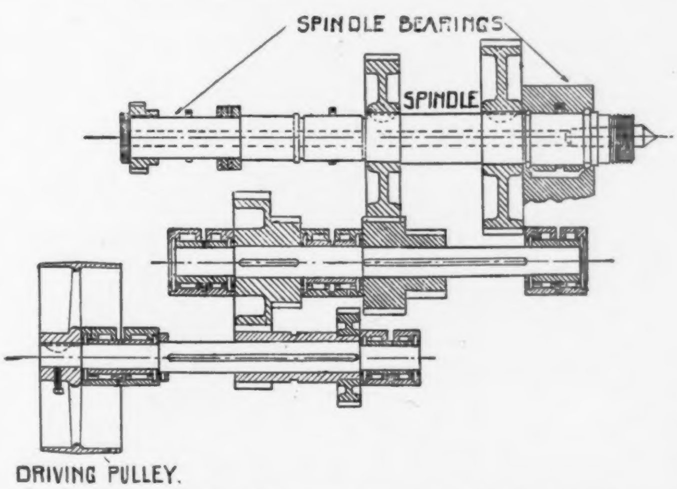
SPINDLE SPEEDS BACK GEAR	SPINDLE SPEEDS OPEN BELT	SURFACE SPEED ON WORK IN FEET PER. MINUTE					PERIPHERY SPEED ON GEARING	H.P. OF DRIVING BELT
		2"	4"	6"	8"	20"		
11		6	12	17	23	57	48	6½
13		7	14	20	27	68	56	8½
17		9	18	27	36	88	72	10½
21		11	22	33	44	110	91	11½
26		13	27	40	54	135	112	16
32		16	33	50	66	167	138	19
39		20	41	61	82	204	168	6½
47		24	49	73	98	247	203	8½
61		32	64	96	128		264	10½
73		38	76	114	153		315	11½
93		49	97	146	195		401	16
112		59	117	176	234		484	19
	143	75	150	224	299		OPEN	6½
	174	91	182	273				8½
	220	115	230				BELT	10½
	268	140	280					11½
	340	178					CUTS	16
	414	216						19



PATENT HEAD LATHE.

The high gear speed of the headstock gearing in the all-geared head drive is due to the design that mounts a large diameter gear upon the lathe spindle, and the absence of open belt speeds for the fastest spindle speeds. In the headstock illustrated the two gears shown upon the spindle are 13 and 15 in. in diameter. Cuts taken on all diameters of work must be driven through one of these gears. Should these diameters be small, from 2 to 4 inches for example, the peripheral speed of the spindle gear in the headstock will be from four to eight times greater than the surface speed upon the work being turned. The result is that with proper cutting speeds, when high speed steel is used, the peripheral speed of the headstock gearing is very great and will thus introduce the element of rapid wear. The power of the drive on the all-geared head construction bears little relation to the actual cutting needs, since the belt travel is constant for all speeds that may be obtained through the gear changes in the headstock.

The diagrams show the spindle speeds, surface speeds on certain diameters, peripheral gear speeds, and horse power of the all-geared head, and a 24-inch patent headstock. It will be seen that the peripheral speeds of the patent head face gear are very much less for the high speeds than on the all-geared head spin-



ARRANGEMENT OF GEARING ON ALL-GEARED HEAD LATHE.

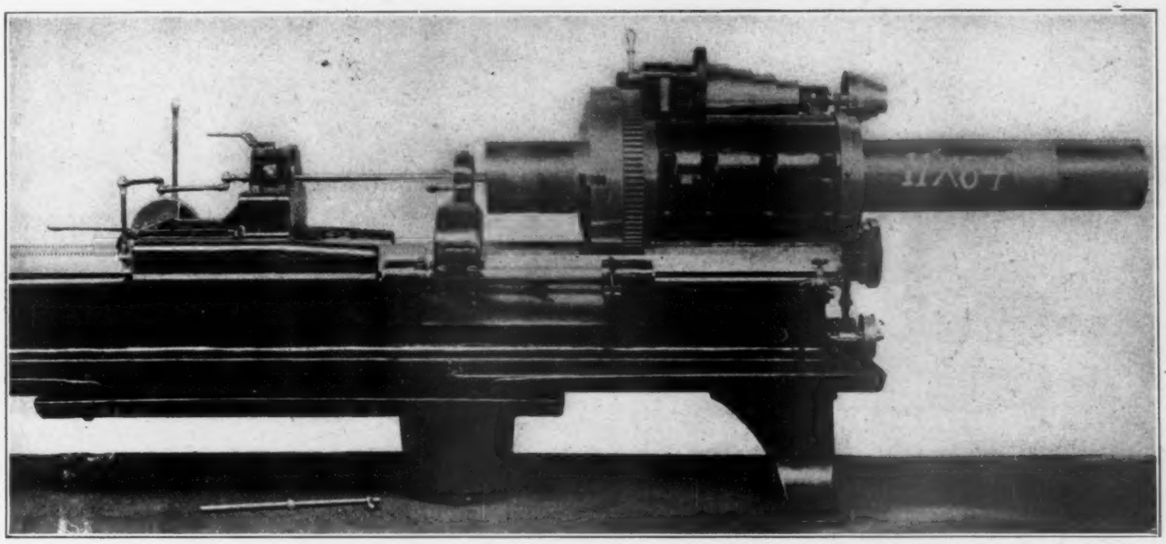
dle gears; also that the six high spindle speeds, when taken on the patent head, are delivered through the open belt.

The gearing in the patent headstock may be adjusted for wear by means of the eccentric bushes carrying the back gear sleeve. Independently of such wear or adjustment, work can be finished with open cuts, thus insuring a perfectly round surface and one free from gear marks. The belt speed may also be regulated to serve the needs of any particular cuts. Twenty horse power will not need to be delivered through the belt to the headstock when the nature of the cut calls for only 5 h.p.

BORING LOCOMOTIVE AXLES.

It is the practice, in several railroad shops, to bore holes through the center of locomotive driving axles to guard against defective material or defects in forging. Such holes must be straight and smooth in order to discover these imperfections. The Springfield Machine Tool Company, Springfield, Ohio, recently made some tests on the smaller of two sizes of machines which have been developed for this purpose, and for boring spindles (February, 1905, page 62). It was found that a 1½ in. hole could be bored at the rate of 90 in. per hour.

Some idea of the heavy construction of the machine may be gained from the photograph. The head consists of a large annular bearing, the front of which carries a three jaw scroll



MACHINE FOR BORING LOCOMOTIVE DRIVING AXLES.

chuck, with the face gear cut in the rear portion of the chuck. This chuck and spindle will receive an axle 11 in. in diameter. The head is provided with eight changes of speed. The carriage is exceptionally long and heavy and is driven by power feed and a double rack, thus insuring a long life, and a steady, powerful forward motion under the heaviest cuts. The carriage is provided with ten changes of speed.

The machine is equipped with a special pump and telescopic brass oil piping. This system of conducting the oil to the tool is unique and convenient, and does away with all the inconveniences of flexible hose piping. The cutting compound, by a special construction of the boring bar, is delivered to the very point of the boring tool, under high pressure, thus forcing the chips from the cutting edge, and back out of the hole.

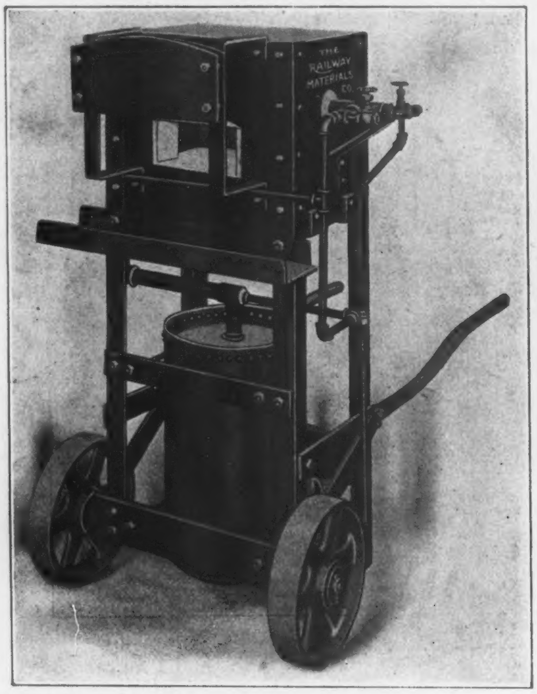
Wastes in Mining.—Attention is directed to the waste of material which is, to a considerable extent, preventable in the mining and extraction of ores in the mining industries, as in lead, zinc, copper, gold and silver mining; and especially to the enormous waste in coal mining, which is equivalent to about one-half of the total product mined, or for the year 1907 about 240,000,000 tons. The aggregate of all these products of mineral waste for the past year is estimated to approximate $1,000,000 per day in value. The mineral production of the United States during the past year was approximately $2,000,000,000, so that this estimated waste is equivalent to more than one-sixth the value of the total production.—*Report of Minerals Section of the National Conservation Commission.*

The Fulton Street Hudson River Tunnel between New York and Jersey City was holed through on March 11. This is the last of the river tunnels at New York City to be finished ready for lining.

STEEL CAR REPAIRS.

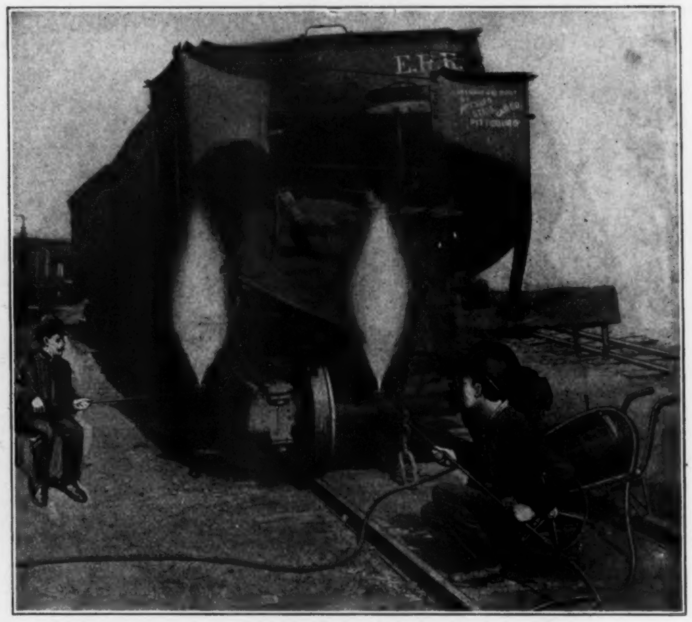
The repairing of steel cars is not a serious problem where proper facilities are provided. The greatest difficulty is with the bent or buckled parts, but they may be readily repaired after some form of heat treatment. In many cases these parts may be straightened in place; in others it is necessary to remove them and heat, straighten and re-rivet them to the car.

A steel car repair plant should have some means of heating bent parts in place; a proper equipment should comprise one or more portable heating outfits for this class of work. Also a furnace capable of taking plates at least 6 ft. in width and 10 ft. in length; this furnace to be used for straightening such parts as have to be removed from the car. The shop and yards should be provided with adequate facilities for riveting. The Railway Materials Company, of New York and Chicago, manufactures a line of heating equipment which is especially designed for use in repairing steel cars. It includes portable heaters for local repairs, several sizes of furnaces for heating plates, and a variety of rivet furnaces.

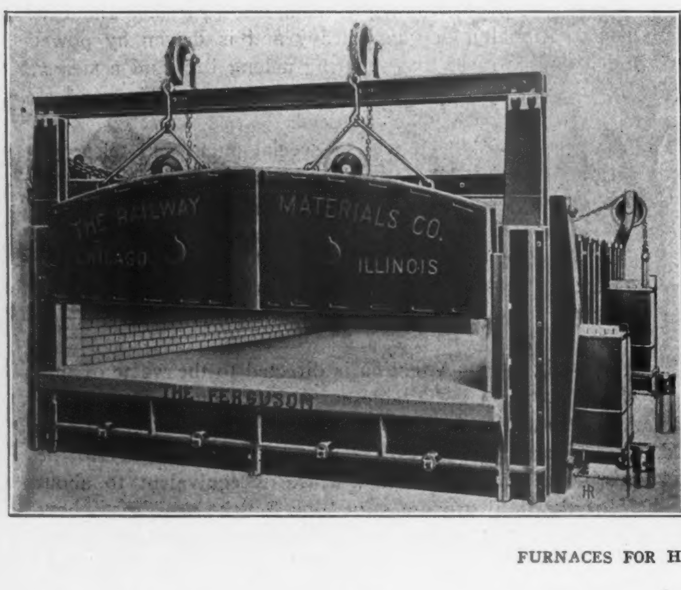


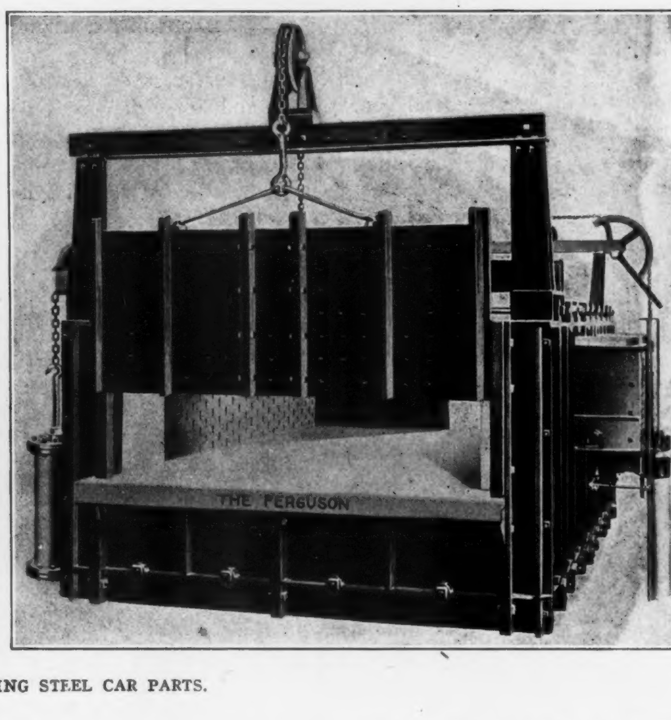
PORTABLE RIVET HEATING FURNACE.

The Ferguson portable heater shown in the illustration affords a rapid and easy means of heating a damaged part locally. It operates with compressed air and consists of a tank mounted on wheels for holding a supply of oil. A mixing valve is provided at the tank for mixing the oil and air. Leading from the valve is a section of hose and a short piece of pipe at the end of which a burner is attached. Here the oil is ignited. The burner gives off an intense heat and rapidly brings the damaged part up to a suitable straightening heat. This heater can be readily handled over yard tracks and elsewhere by one person.


PORTABLE HEATERS.

For heating plates or other parts which have to be removed for straightening, this company manufactures a line of furnaces, two sizes of which are shown on the accompanying photos. One of these is 6 ft. 8 in. in width inside and 10 ft. in length. It has a door at one end the full width of the furnace; also a smaller door at the opposite end; on one side an additional burner is set at the floor line, thus providing admirable facilities for locally heating a sill or other part. The other furnace is larger, being 8 ft. 10 in. in width and 14 ft. in length inside. It also has a door the full width of the furnace at one end, and a smaller door at the other end. The larger door is constructed to lift in sections, which are independently operated by means of air hoist lifts. It is also equipped with an extra burner at the floor line for heating members locally. These furnaces are substantially





FURNACES FOR HEATING STEEL CAR PARTS.

constructed and are lined throughout with a heavy lining of high-grade fire brick; they are sold erected in position and ready to operate. They are intended to cperate with crude or fuel oil supplied to the burners at a pressure of from 5 to 10 lbs. A fan blast pressure of 8 ozs. per sq. in. is used, compressed air not being required.

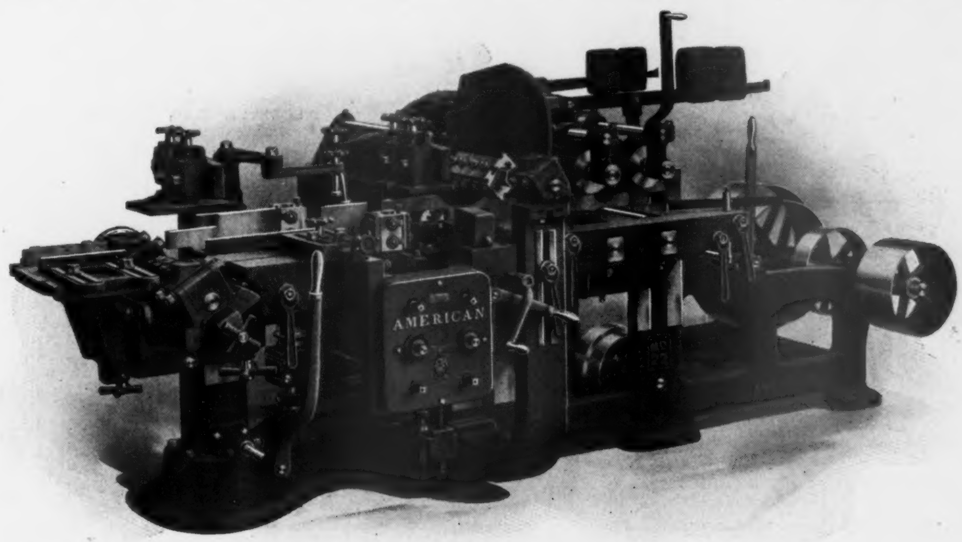
A portable outfit for heating rivets is also manufactured by this company and is shown in one of the illustrations. It carries its own fuel supply and operates with compressed air. Its weight is approximately 550 lbs. with a full supply of fuel and it may be easily transported about the yards. The tank holds about ten gallons of oil, or a sufficient quantity for a day's run.

NEW OUTSIDE MOULDER.

A number of important improvements have been made in the new American outside moulders. These will work 9, 10, 12 and 14 in. wide by 5 in. thick. The cylinder boxes are of a patent side clamping flange type which prevent the operator from screwing the top portion of the boxes down on the shaft so tightly as to cause the shaft to heat and often to spring. With the improved method the cap is held in position by drawing together the sides of the boxes with heavy bolts; as the cap is plain tapering, it is impossible to force itself up.

With the older type moulders it was necessary, in order to adjust the side spindles vertically, to loosen four bolts in each cap, or eight in all, and to re-tighten these after the spindle was adjusted. Now one movement of a lever locks and unlocks both caps and the spindle may be adjusted very quickly. This is true of the inside and outside side spindles, as well as of the top headstock. It has been necessary, up to the present time, in removing the lower feed rolls in moulders to almost entirely dismantle the machine, consuming at least half a day; on the new machine, the lower feed rolls can be removed and new feed rolls be put in and the machine be ready for work in not over ten minutes. This detachable plate or chip breaker in front of the bottom head can be adjusted from the top of the table. The adjustable guide back of the outside head has a screw adjustment of 4 in. without disturbing the base of the guide. The bed carries the inside and outside headstock; each headstock has an independent adjustment.

The feed works are exceptionally heavy, having four 6 in. driven rolls; a new direct gear drive makes it a most positive and powerful feeding device, without the use of heavy weights. There is a spring intervening between the weight lever and rolls to minimize any jar when dropping. The top rolls and the hoods for the top head can be raised and lowered by a lever placed conveniently. This will admit placing forms, setting knives, or slipping back stock when desired. The top rolls are provided with an outside bearing, which can be easily removed for changing the rolls. The feed is arranged with a new gear change, furnishing six rates of feed, 10, 15, 20, 30, 40 and 60 feet per minute, without extra pulleys or extra gears. The top head has a lateral adjustment; the bottom head has lateral and vertical adjustments controlled by hand wheels. The hood for the top head is fitted with an adjustable chip breaker, made in three interchangeable sections. It can be thrown up and back across the machine, giv-



IMPROVED OUTSIDE MOULDER.

feature is appreciated when it is desired to change from plain to corrugated feed rolls for running wet stock. Another important feature, which is new on outside machines, is the provision for stopping and starting the feed from either end of the machine.

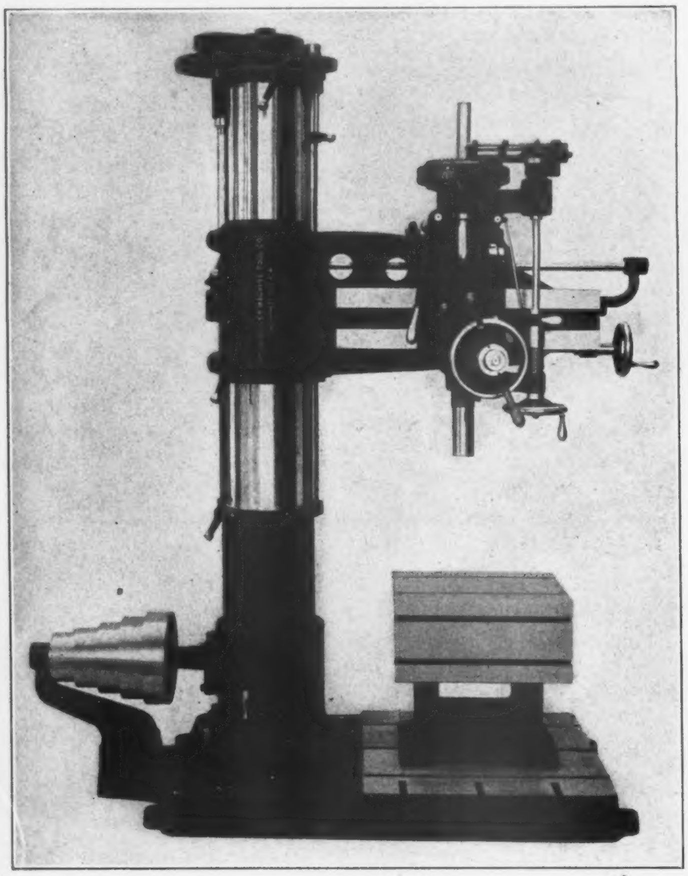
The frame is heavy and is cast in one piece. The heavy column at the rear end makes a substantial support for the end of the table, and also for the under cutter-head. The top arbor is provided with an adjustable outside bearing, bolted to the base of the frame, for lining up the arbor when necessary; at the top it is secured firmly by a bolt passing through the table and the frame. The bed is heavy and securely gibbed to the frame, with proper provision for taking up the wear; it is raised and lowered by a large screw on ball bearings, operated by a crank. There is a reversible bed plate directly under the top head—one side plain, the other side grooved ½ in. deep and ½ in. wide, allowing knives to extend below the face of the bed, if necessary. The extension of the bed, beyond the lower head, drops down, giving free access to the cutter head, without disturbing the guides. The ing free access to the top-head cutters. The cutting circle of all heads is 6⅛ in. All chip breakers are adjustable, permitting 3 in. extension of knives on top and bottom heads (giving 12 in. maximum swing), and 2½ in. on side heads. The side heads raise and lower with the table, and can be set to an angle and be moved vertically and laterally without changing the angle. The outside head is arranged with an adjustable weighted chip breaker, which travels with the head. The inside head can be adjusted from the front or rear side of the machine. Both side heads can be adjusted vertically from the top or bottom of the headstock. The step box for the side spindles has self-oiling, self-leveling steps. One movement of the lever locks the headstocks firmly. These machines are made by the American Wood Working Machinery Company of Rochester, N. Y.

NEW YORK TRAIN SERVICE RECORD.—The record of the New York Public Service Commission shows that during the month of January, 53,560 passenger trains were run in the State of New York, and of these 86 per cent. were on time.

TWO-AND-ONE-HALF FOOT RADIAL DRILL.

This drill is of simple and substantial construction, and while it embodies several of the good points of the standard line of radial drills made by the Mueller Machine Tool Company of Cincinnati, is not an expensive tool, but is intended for a class of work which does not require the higher grade machines of this type.

The stationary column is of heavy section throughout, making it strong and rigid. The arm is of tube section and cannot be twisted under severe service. It is clamped to the column by the two handles and may be raised and lowered rapidly; it is instantly controlled by a lever on the cap, within easy reach of the operator. The bronze plate attached to the arm enables the operator to select the proper speeds which may be changed while the machine is in operation. The head is traversed through a double pitch screw and is equipped with a locking device.

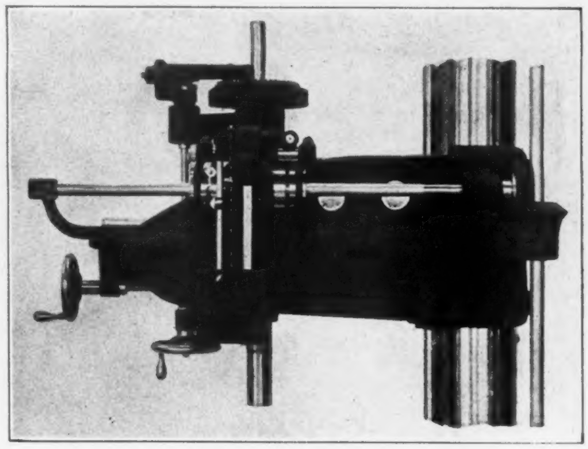


TWO-AND-ONE-HALF-FOOT RADIAL DRILL.

The spindle has ten changes of speed, all instantly available. It has quick advance and return and is counterbalanced. A tapping attachment is provided and is so arranged that an adjustable gauge screw causes the tap to slip when it reaches the bottom of a hole. The starting, stopping and reversing lever is located on the head directly in front of the operator, making it very convenient. The automatic feed has four changes and can be used as either a positive or friction feed. Changes may be made while the drill is at work. The feed is adapted for the use of high speed drills, etc. The gears, both spur and mitre, are planed theoretically correct and the shafts, as well as the column, are ground to size. This drill is also made in the 3 and 3½ ft. sizes.

COLLEGE MEN IN RAILROAD SERVICE.

E. H. Harriman recently wrote to a Yale publication on college training for railway men, stating in part: "A high school boy is more likely to know arithmetic and to be able to prepare a clear and concise statement. However, in the long run, the college men should pull out ahead, as hard work and continued effort will alone lead to success, while pull can't last. A college education is, in the beginning, a real disadvantage, and I have found that in every case the high school boy does better work than the college man for the first few years. However, as soon as the college man has got back to first principles, he will go ahead much faster than his less educated rival. His mind is, naturally, better developed and more capable of grasping the fine points of the business. On the other hand, the high school boy, being younger, is more adaptable and has not, in most cases, the irregular habits of the college man. No matter how well educated a man may be, he must start in railroading at the very bottom. He has no fixed home; he is like a naval officer, always at sea, and moreover, he is always working to the limit of his endurance. It is the hardest life I know, and yet one of the most pleasant. It teaches a knowledge of men, and in this way is the best training for any profession. My advice to the college man expecting to enter railroading and hoping to have an easy life is 'Don't'; but to the man who does not mind the hardest kind of work, who will not quit under early disappointments, and who wishes to have the most interesting sort of a career, 'By all means do.'"



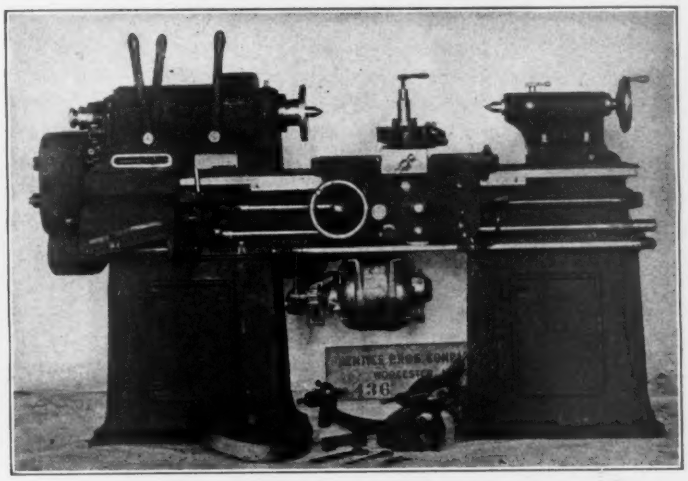
REAR VIEW OF ARM OF RADIAL DRILL.

Loss of Life in Coal Mines.—Even more serious than the question of the waste of materials is the excessive loss of life in our mining operations. During the past year in coal mines alone more than 3,000 men were killed and more than 7,000 injured. The number of men killed in the United States for each 1,000 men employed in the mines is from two to four times as great as it is in other coal-mining countries. Of course, it is not to be expected that the coal miners in the United States at 75 cents per ton for their coal at the mine can take the elaborate precautions in behalf of the safety of the men and the protection of waste of fuel which are taken in European countries where the value of the coal at the mine is more than twice this figure; but the American people cannot afford to demand cheap coal at the cost of human life and the waste of the heritage which belongs to the next generation. The miners and the operators are anxious to inaugurate these needed reforms, and certainly the American people are ready and willing to pay whatever increase in the cost of fuel may be found necessary in order to guarantee the safety of the miner and the saving of the fuel which belongs to the next generation.—*Report of Minerals Section of the National Conservation Commission.*

Pressures in the Metric System.—In the metric system, fluid pressure is expressed in kilograms per square centimeter. The constant for converting into pounds per square inch is 14.22, a kilogram per square centimeter being equal to 14.22 pounds per square inch. In scientific work, fluid pressures are commonly measured in atmospheres, this being a universal natural standard, and it happens that for rough approximations, a kilogram pressure per square centimeter is practically equal to one atmosphere.—*Machinery.*

AN INTERESTING MOTOR APPLICATION TO A HIGH-SPEED GEARED-HEAD LATHE.

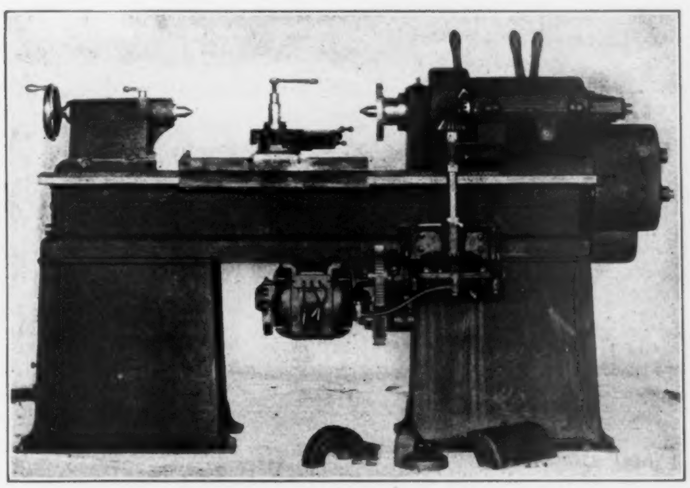
In applying a motor drive to their high-speed geared-head lathes, twenty-two inches in size and under, Prentice Bros. Company of Worcester, Mass., place the motor underneath the bed, as shown in the illustrations. On the larger lathes the size of the motor does not permit doing this, and it is placed at the rear of the headstock. The geared-head provides eight changes of spindle speed, without stopping the lathe, and the use of a constant speed motor having about 1200 r.p.m., and of either the direct or alternating current type, is therefore recommended. By using a variable speed motor a great number of speed changes may be furnished, but ordinarily these are not needed.



UNIQUE MCTOR APPLICATION TO HIGH-SPEED LATHE.

Where a constant speed motor is applied, as shown in the photos, the lathe spindle may be started, stopped or reversed, without stopping the motor, by the handle on the spline shaft at the lower right hand corner of the carriage. Time and power are thus saved over the method commonly used of reversing the motor.

Motion is transmitted from the motor to the headstock through the train of spur gearing and the bevel gears at the top and bottom of the vertical shaft at the rear. The direction of the vertical shaft is stopped, or changed, by shifting the two bevel gears on the horizontal shaft, which engage with the one at the lower end of the vertical shaft. These gears are controlled from the handle on the spline shaft at the front of the machine.



MOTOR APPLICATION TO HIGH-SPEED LATHE, REAR VIEW.

In cutting threads it is much easier to cut to a shoulder with this arrangement, as the controlling lever needs to be moved only two or three inches and works more easily than the reversible controller on a motor.

FORGED STEEL HYDRAULIC JACKS.

The latest development in the hydraulic jack field is a design forged entirely out of open hearth, fluid compressed steel which is being put on the market by the Duff Manufacturing Company, Pittsburgh. The patents covering the special features and construction are held by the Bethlehem Steel Co. who designed and perfected it and do the special forging necessary. It is called the Duff-Bethlehem Hydraulic Jack and because of its steel construction weighs from 30 to 60 per cent. less than other hydraulic jacks of the same capacity and lift.

One of the greatest troubles with hydraulic jacks has been the packing, particularly that at the bottom of the cylinder. In this new design both the cylinder and ram have solid bottoms requiring no packing or joints at these points. The ram bottom is also forged integral with the pump socket and requires no packing at that point. In fact, there are practically only two small packings in the entire jack.

Careful attention has been given to obtaining the minimum number of parts in the operating mechanism and to make these as simple and strong as possible. These parts can be easily replaced if necessary without special tools. The jacks will extend to their full length when placed at any angle. The load may be tripped or may be lowered as slowly as desired, or stopped at any point when lowering.

Jacks of all types and capacities are made to this design. The illustrations show two types suited to railroad uses. The low or telescope type is fitted with an improved duplex pump which automatically regulates the change of speed proportional to the load being lifted. This type is regularly made with capacities from 30 to 300 tons and can be procured in higher capacities if desired.

FORGED STEEL HYDRAULIC JACKS FOR RAILROADS.

The Duff Manufacturing Co. by the addition of these hydraulic jacks is now prepared to furnish practically every kind of lifting jack for every possible condition or purpose. It will be remembered that it previously had a large line of Barrett jacks, Duff ball bearing screw jacks and other special designs.

THE EFFECT OF SUPERHEATED STEAM on cast-iron pipe fittings was strikingly shown in a 20-in. tee recently removed from a main steam line in the Pratt street power plant of the United Railways & Electric Co., Baltimore, Md. The main had been in service for three years, carrying steam at 160 lb. pressure with a superheat of about 500 deg. Fahr. above saturation. The fitting was found to have grown nearly ¾ in. in length and was fully 1 in. larger in diameter than when it was installed. The inner surfaces were covered with a hard reddish oxide in which no cracks were visible, but the outer surfaces were covered with fine hair cracks, some of which had in places opened up to about ⅛ in. Steam had begun to leak through these larger cracks, causing the removal of the tee.—*Engineering News.*

PNEUMATIC STAYBOLT NIPPER.

A pneumatic staybolt nipper, developed by C. K. Lassiter, is shown in the accompanying illustration. The device is compact and convenient, being about 42 in. long and 20 in. in diameter at its largest part. It is made entirely of steel, weighing only 450 lbs. The action is simple, the piston forcing a wedge between the tapered bearings on the blades, a suitable spring drawing them back into position for the next stroke. The bail trunnions are

PNEUMATIC STAYBOLT NIPPER.

on a ring, allowing the nipper to be operated in any position. A three way operating valve is placed in the center of the cylinder head for the air connection.

The nipper has a capacity for 1¼ in. staybolts when working with 80 lbs. pressure. It is sold by The Walter H. Foster Company, New York.

STEAM RAILWAY ELECTRIFICATION IN BOSTON.

This subject received special attention in the report of the Massachusetts Railroad Commission recently submitted to the Legislature. In the commission's report for 1907 the statement was made that the railroads should investigate at the earliest possible date the whole question of electrification of their lines running into the city. The last report contains letters from the various companies stating what they have done up to the present time.

President Mellen, of the New York, New Haven & Hartford R. R., reported that the company considered the interruptions to its electric service between Stamford and New York no greater nor more frequent than was the case when steam was in use. It is not prepared to state, however, that there is any economy in the substitution of electric traction for steam, but on the contrary, it believes the expense is very much greater. In view of the short time the company has had an opportunity to gain definite knowledge by running its trains electrically into New York, it believes that the Boston public will make no mistake in waiting a while longer for the installation of electric traction in Massachusetts, for by such waiting the vexation, delay and embarrassment of experiment will be avoided, and the work will have advanced to a stage that will result in a better installation in some respects, and for a smaller outlay, than the pioneer work on the west end of the line.

President Tuttle of the Boston & Maine R. R. states that his company uses coke as a fuel on a very large portion of the local passenger service in the vicinity of Boston, and therefore feels that there is not the necessity of introducing electrification that exists where a fuel giving off more smoke and dirt is employed. The company is watching, however, the experiments and results obtained near New York, but feels that they do not indicate the desirability of electrifying the Boston service at the present time.

The Boston & Albany R. R., through Vice-President A. H. Smith, has prepared preliminary plans for the electrification of some of its lines into Boston, but it feels that the large sums necessary to carry out such work could be better used for other improvements at the present time, particularly in view of the very short actual experience in the operation of heavy train service by electricity.

The railroad commission publishes the full text of these communications from the various railroads without any comments.

A STRONGER SHANK FOR DRILLS.

The tangs on taper shank drills have not proved strong enough under the severe service of modern practice and are frequently twisted off or broken. To overcome this the Standard Tool Company, of Cleveland, O., is putting drills on the market with a new standard of shank, known as the "Stantool" shank. This shank is shorter and the tang is much heavier than the old standard, thus practically eliminating the possibility of broken tangs. The contrast between the old and new shanks is clearly shown by the accompanying illustrations. This company is also prepared to furnish sockets and sleeves to fit all modern makes of drill presses on the market, and arranged to take the new "Stantool" shank.

"STANTOOL" SHANK.

MORSE STANDARD SHANK.

DAILY REVIEW.—The Daily Railway & Engineering Review issued during the convention of American Railway Engineering & Maintenance of Way Association in Chicago, March 15-19, was greatly appreciated by both the members attending and the exhibitors at the Coliseum. The convention, exhibition and the "daily" were all grand successes.

BOOKS.

The Railway Locomotive. By Vaughan Pendred, M.I.M.E. Cloth. 5½ x 8¼ in. 310 pages. Illustrated. Published by D. Van Nostrand Co., 23 Murray St., New York. Price, $2.00, net.

It is stated by the author in his introduction, that in the many books written about the locomotive, it has always been treated anatomically, not physiologically, and he has attempted in this work to break new ground. There is practically nothing given on the history of the locomotive, the endeavor being to describe the modern machine and to explain why it is what it is. He has divided his subject into three parts—vehicle, steam generator and steam engine—and discusses each in a broad, general man-

ner. Illustrations of present day practice are freely given, and while these are usually taken from British designs, the principles demonstrated are fundamental and apply equally well to American practice. Foot notes and other reference to more extensive and detailed treatises on the different phases of the subjects are numerous. This book will be found to be particularly suited to men who have specialized in some other branch of engineering and wish to get posted on the locomotive.

Block Signal and Train Control Report to the Interstate Commerce Commission. 77 pages. 6 x 9. Illustrated. Obtained upon request to the Interstate Commerce Commission, Washington, D. C.

The first annual report of the committee appointed to investigate the subject of block signals and train control is now being issued by the Interstate Commerce Commission. It contains considerable information in connection with cab signaling and complete descriptions of foreign block signaling equipment of several kinds.

PERSONALS.

Malcolm Baxter, master mechanic of the Western Ohio Railway, has resigned, effective April 1.

L. H. Raymond, master mechanic of the New York Central R. R., at High Bridge, N. Y., has resigned.

G. W. Robb has been appointed an assistant master mechanic of the Grand Trunk Pacific Ry., with office at Rivers, Man.

George F. Hennessey has been appointed the roundhouse foreman of the Chicago, Milwaukee & St. Paul Ry., at Janesville, Wis.

Roy S. Parker has been appointed the general storekeeper of the Kansas City, Mexico & Orient Ry., with temporary office at Fairview, Okla.

W. C. Weigel has been appointed the general time and work inspector of the motive power department of the Union Pacific R. R., with office at Omaha, Neb.

C. B. Smyth, assistant mechanical engineer of the Union Pacific R. R., has resigned and has been appointed the superintendent of the McKeen Motor Car Co., Omaha, Neb.

E. H. Hohenstein has been appointed a general boiler inspector of the Chicago, Rock Island & Pacific Ry., with office at Horton, Kan., succeeding W. B. Embury, assigned to other duties.

E. V. Williams has been appointed a general foreman, locomotive department of the New York Central & Hudson River R. R., with office at Avis, Pa., succeeding H. B. Whipple, promoted.

A. J. Edmonds, a general car and locomotive foreman for Sioux City and Dakota divisions of the Chicago, Milwaukee & St. Paul Ry., has been transferred to Madison, Wis.

G. E. Johnson has been appointed the master mechanic of the Wymore division of the Chicago, Burlington & Quincy R. R., with office at Wymore, Neb., succeeding A. B. Pirie, assigned to other duties.

B. W. Benedict has been appointed bonus supervisor of the Atchison, Topeka & Santa Fe Ry. at Topeka, Kan., and will have territorial charge of bonus work on the Eastern Grand division and functional supervision over standardization of schedules.

Euclid E. Grist, assistant general foreman of the Ft. Wayne, Ind., shops of the Pennsylvania Lines West, has been appointed an assistant master mechanic, with office at Ft. Wayne. Allen S. Courtney succeeds Mr. Grist.

C. H. Seabrook, general master mechanic of the Trinity & Brazos Valley Ry., has been appointed the superintendent of motive power and equipment. The office of general master mechanic has been abolished.

W. B. Embury has been appointed the master mechanic of the Oklahoma & Pan Handle divisions of the Chicago, Rock Island & Pacific Ry., with office at Chickasha, Okla., succeeding W. J. Monroe, resigned.

E. V. Dexter, purchasing agent of the Mexican Central Ry., has resigned, and all purchasing and sales for account of the National Railways of Mexico will in future be done by J. H. Guess, purchasing and fuel agent, with office at Mexico City.

W. A. Bennett has been appointed road foreman of engines of the Chicago, Burlington & Quincy Ry. at Edgemont, S. Dak., with jurisdiction over the line from Alliance, S. Dak., to Deadwood, and over all branches in the Black Hills.

L. P. Breckenridge, professor of mechanical engineering at the University of Illinois, has resigned to take effect at the end of the college year and on September 1 will assume charge of the Sheffield Scientific School at Yale in place of Prof. Charles B. Richards, retired.

Thomas A. Lawes, the mechanical engineer of the New York, Chicago & St. Louis R. R., and formerly the superintendent of motive power of the Chicago & Eastern Illinois R. R., has been appointed the superintendent of motive power of the Southern Indiana Ry., with headquarters at Bedford, Ind.

L. B. Morehead has been appointed the mechanical engineer of the New York, Chicago and St. Louis R. R., vice T. A. Lawes, resigned. Mr. Morehead was formerly the chief draughtsman of the Louisville and Nashville Ry. and lately has been an elevation draughtsman for the American Locomotive Company at Schenectady. His office is at Cleveland.

W. W. Atterbury, general manager of the Pennsylvania Lines east of Pittsburg has been elected fifth vice-president in charge of the transportation department of the Pennsylvania Railroad. Mr. Atterbury graduated from Yale University in 1886 and entered the service of the P. R. R. as an apprentice in the Altoona shops. From 1889 to 1903 he successively held positions as road foreman of engines; assistant engineer of motive power, northwest system; master mechanic, Fort Wayne; general superintendent of motive power of lines east and general manager of lines east.

The mechanical department of the National Railways of Mexico has been divided into two districts, the Eastern and the Western. The Eastern district will be the main line from Mexico City to Laredo, with all branches, including the main line from Mexico City to San Juan del Rio, the narrow gauge system, the Cuernavaca district and the districts Gonzalez to Acambaro, Gonzalez to Jaral del Valle, Monterey to Hipolito and Paredon to Saltillo. The Western district will be the main line from San Juan del Rio to Ciudad Juarez, inclusive, and all branches west, and will take care of all engines running into western terminals, such as those running between San Luis and Aguascalientes, Torreon to Saltillo and Gomez Palacio to Hipolito. The Eastern district will be in charge of superintendent of mechanical department M. J. Schneider, with office at San Luis Potosi. The Western district will be in charge of superintendent of mechanical department J. J. Waters, with office at Aguascalientes.

NOTES.

Crocker-Wheeler Co.—Among the recent orders booked by the above company are eight motors, aggregating 170 H. P. for the Alliance Machine Co., Alliance, Ohio; a 22 H. P. motor for the Newton Machine Tool Co.; and a number of small motors for Yawman & Erbe, of Rochester, N. Y.

Burton W. Mudge & Brother.—The above firm, 544 Commercial National Bank Building, Chicago, has been appointed western representative for the McInnes Steel Company of Corry, Pa., who handle a complete line of high grade tool steel of all kinds. A complete stock will be carried at Chicago, in the warehouse at No. 52 West Washington street.

The Union Switch & Signal Co.—The annual meeting of this company was held on March 9. The following were elected directors: George Westinghouse, Robert Pitcairn, William Conway, George C. Smith, Thomas Rodd, H. G. Prout, and James J. Donnell. It was announced that unfilled orders to the amount of $1,357,000 were on the books. Contracts were reported as coming in more freely than at any time for over a year.

The Rockwell Furnace Company.—This company has been awarded the contract covering the complete furnace equipment for the new Locomotive Shops of the Delaware, Lackawanna & Western R. R., at Scranton, Pa. It consists of thirty-five of the latest type furnaces operated with 800 B. T. U. water gas, made in Loomis Pettibone producers. These shops are to be in operation in three months, and embody throughout the latest and most improved machinery and equipment selected after a careful inspection of a large number of modern railway and industrial plants throughout the country.

Producer Gas Tests.—The long series of producer gas tests on various grades of bituminous coal, conducted by the U. S. Geological Survey at the St. Louis Exposition, have been productive of such fruitful results that the testing work has been perpetuated and the government has secured for this purpose a 140 H. P. Westinghouse 3-cylinder vertical single-acting gas engine. This engine is of the same type as that installed at St. Louis, upon which all of the producer gas tests were made. An important schedule of experimental work has been laid out by the government engineers and tests will be run on all classes of soft coals, lignites, peat, etc.

Joel S. Coffin received on February 27 a remarkably touching tribute from his friends and former associates in the Galena Oil Company, expressing their regard for him upon his recent retirement to become Vice-President of the American Brake Shoe & Foundry Company. Galena men from all parts of the country assembled in the office of Mr. Coffin, presenting him with a beautiful loving cup engraved with their fac simile signatures, also a magnificent mahogany office desk and handsome specially designed ink stand. Gifts from friends are not unusual upon the withdrawal of a highly esteemed officer and associate, but it is given to few men to inspire the staunch affection of strong, successful men such as was revealed on this occasion. The gifts themselves, handsome as they are, were only an incident in this demonstration of affectionate regard. While the affair was quiet and private, it is fitting that news of it should be extended outside the official family concerned to the hosts of others who admire and honor Mr. Coffin.

CATALOGS.

IN WRITING FOR THESE PLEASE MENTION THIS JOURNAL.

Lubricating the Motor.—The Joseph Dixon Crucible Company, Jersey City, N. J., is issuing a booklet which deals with the subject of the lubrication of automobiles, motor boats and motor cycles. The subject is considered in chapters, each covering a separate part of the motor.

Quride.—A booklet being issued by the Picrome Hide Co., 1417 N. Salina St., Syracuse, N. Y., explains the qualities of "Quride," which is produced by treating hides by a patented chemical process, making a tough, homogeneous, insoluble product which will not become brittle. It is used in making noiseless gears, belt lacing, packing, etc.

Aids to Shippers.—Oelrichs & Co., 5 Greenwich street, New York, is sending out a 72-page book containing a large amount of information of great value to all engaged in the export and import trade. It includes a table of foreign monies, weights, and measures, with U. S. equivalent, as well as tariffs, custom requirements, etc. of foreign countries.

High-Duty Turbine Pumps.—Bulletin G of the Lea Equipment Company, 186 Liberty street, New York, very completely illustrates and describes a line of high efficiency turbine pumps for heads from 7 to 1000 ft., and capacities ranging from 75 to 30,000 gallons per minute. An account of some tests by Prof. Denton at Stevens' Institute are included.

Coal and Ash Handling.—Catalog 32-A of the Jeffery Manufacturing Co., Columbus, Ohio, contains 72 pages largely given up to photographs and elevation drawings of coal and ash handling equipments for power plants covering a wide range of capacities and arrangements. Some most interesting and suggestive arrangements are clearly shown in this manner.

Noiseless Gears.—The New Process Raw Hide Co., Syracuse, N. Y., is sending out a small catalog which fully explains how the "new process" differs from other raw hides, by fully describing the process and giving results of actual service. Gears made of this material can be obtained in almost any practical size or type. It also has other uses which are illustrated in this book.

Reinforced Concrete Chimneys.—The Weber Company, 929 Marquette Building, Chicago, is sending out a very interesting account of the origin and development of concrete chimneys. This company built the 300-ft. stack for the American Smelting and Refining Co., at Tacoma, Wash., which is said to be the highest and largest chimney in the world.

Machine Tool Motors.—Bulletin No. 4649 of the General Electric Co. discusses the advantages and disadvantages of the independent and group method of driving railroad shop tools. Illustrations of electrically driven tools are numerous. Tables of costs of tools for a shop arranged to drive by both of the methods are given and the suitability of alternating current in certain cases is discussed.

Users of C.-W. Generators.—A list of engine type D. C. generators sold by the Crocker-Wheeler Company, Ampere, N. J., is given in its Bulletin, No. 110. This list, covering fifteen pages, gives the names and addresses of companies and individuals using these generators. In several items no address is given, these being U. S. battleships, several of which are equipped with C.-W. generators.

Bettendorf Bears.—The virtues of the Bettendorf truck are very cleverly proclaimed in rhyme in the story of the visit of the S. M. P. of P. D. Q. to the shops of the Animal Line, by B. V. Crandall, which is being issued with the compliments of the Bettendorf Axle Co., Davenport, Ia. The colored illustrations are pleasing in every way and the fact that "every bear in that busy shop was through at noon and ready to stop," is conclusive evidence that the Animal Line was not troubled with truck repairs.

Under-Feed Stokers.—The Taylor stoker is said to be the only stoker in which green or uncoked fuel is fed under coked and burning fuel, while at the same time the entire fuel bed is moved by gravity down an incline in such a manner as to rid itself of ash and clinker. The construction, arrangement and principles of this stoker are fully given in a catalog being issued by the American Ship Windlass Co., Providence, R. I. This is fully illustrated and shows the stoker applied to practically all different types of boilers.

The Iron and Steel Department Store.—Joseph T. Ryerson & Son, Chicago, whose new warehouses at Sixteenth and Rockwell streets have an area of 750,000 sq. ft. and a capacity for 150,000 tons, are issuing a very attractive book descriptive of the excellent facilities at the new location which permit them to fill orders of any kind for iron or steel at very short notice. Excellent half-tones of views around the plant show the orderly and convenient arrangement of the very large stock. Illustrations of the extensive line of boiler shop machine tools handled by this company are also included.

Drills, Reamers, Cutters.—Catalog No. 16 of the Standard Tool Co., Cleveland, Ohio, is divided into four principal sections. The first section is given up to drills, sockets, etc., and covers 120 pages. It shows twist drills of all types in all sizes and with all kinds of shanks, drills with oil grooves, left handed drills, drills in metric sizes, and fluted drills, each being accompanied by a table giving complete dimensions and prices. The second section of 52 pages treats reamers in a like manner; the third, taps; and the fourth, milling cutters, chucks, etc. Taken all together this is a most complete reference for small tools and is accompanied by a full code for telegraphic orders.

Drafting Room Equipment.—The thirty-third edition of the catalog of Keuffel & Esser Co., 127 Fulton street, New York, contains 540 pages massed full of illustrations and prices of instruments, tools, furniture, appliances, etc., of interest to every engineer and draftsman. The product of this firm is too well known to require any mention of particular articles and it is sufficient to say that it is impossible to think of anything needed by the draughtsman or engineer in his work that is not shown in this book. Among the new products might be mentioned the Champion continuous blue printing machine, which offers many features of advantage over the earlier types of blue printing machines.

Grinding Wheels and Machinery.—Alundum is made by fusing the mineral Bauxite, chemically the purest form of aluminum oxide found in nature, in the intense heat of the electric furnace, and because of its peculiar combination of hardness, sharpness and temper, is the best abrasive material known. The way in which this material or mineral is made is fully described in a catalog being issued by the Norton Company, Worcester, Mass., who use it exclusively in manufacturing grinding wheels. The method of making and testing the wheels suitable for different purposes is also explained. The catalog includes illustrations of a great variety of shapes of wheels as well as a number of grinding machines, etc.

MALLET ARTICULATED COMPOUND LOCOMOTIVE

SOUTHERN PACIFIC COMPANY.

The Baldwin Locomotive Works has recently completed two Mallet articulated compound locomotives for the Southern Pacific Company, which are the heaviest locomotives in the world. They will be used on the Sacramento Division of that railroad between Roseville and Truckee, where the maximum grade is 116 ft. per mile, and will have a rating of 1212 tons, exclusive of engine and tender, over that division. The locomotives have a total weight of 425,900 lbs, of which 394,150 lbs. is on drivers. The calculated tractive effort is 94,640 lbs. They are of the 2-8-8-2 type, the front truck carrying 14,500 lbs. and the back truck 17,250 lbs.

The most notable departure from previous locomotive practice in this case is found in the incorporation of the feed water heater forming a part of the boiler and in the introduction of the reheater between the high and low pressure cylinders. This, of course, is the largest number of wheels ever put under a single locomotive and the arrangement for removing the forward section of the boiler is entirely new.

The accompanying table has been prepared to permit a comparison between the four most notable examples of Mallet articulated compound locomotives that have been built in this country. From this it will be seen that while the Southern Pacific engine is by far the largest in total weight, it has not quite the tractive effort, working compound, that is given by the Erie locomotive, which carries all of its weight on drivers, and as a result has a higher factor of adhesion. The increased tractive effort of the Erie, however, is largely due to the smaller diameter of drivers and increased steam pressure, it being designed altogether for pushing service and not for regular road work, which, we understand, the Southern Pacific is intended for.

Road	S. P.	Erie	G. N.	B. & O.
Type	2-8-8-2	0-8-8-0	2 6 6-2	0-6-6-0
Builder	Baldwin	Amer.	Baldwin	Amer.
Total Wgt., lbs.	425900	410000	355000	334500
Wgt. on Drivers, lbs.	394150	410000	316000	334500
Tractive effort (comp.), lbs.	94640	94800*	71600	70000*
Diam. Cylinders, in.	26 & 40	25 & 39	21½ & 33	20 & 32
Stroke, in.	30	28	32	32
Steam Pressure, lbs.	200	215	200	235
Diam. Drivers, in.	57	51	55	56
Diam. Boiler, in.	84	84	84	84
Total Heating Surface	6393†	5313.7	5703	5600
Wgt. on Drivers ÷ Tractive Effort	4.18	4.32	4.4	4.75
Total Wgt. ÷ Tractive Effort	4.51	4.32	4.95	4.75
Tractive Effort × Diam. Driv. ÷ Heating Surf.	843	910	690	700
Heating Surface ÷ Grate Area	93.4	53.14	73	77.3
Wgt. Drivers ÷ Heating Surface	61.0	76.9	59.2	59.5
See American Engineer	—	1906 p429	1906 p371	1904 p237

*This is not the maximum tractive effort of these locomotives, since they are fitted with an intercepting valve and separate exhaust pipe, allowing them to be worked simple and thus increase the tractive effort given by 20%.

†Includes Feed Water Heater.

The illustrations on the following pages show the general design and the boiler arrangement of the Southern Pacific locomotive, and in a later issue will be given some of the more interesting details of this design.

Oil is to be used for fuel, but it is evident from the construction of the firebox that coal can be burned, although probably not fast enough to develop the full power of the locomotive. The boiler is of the straight type, 84 in. in diameter at the front end. Ahead of the firebox is the barrel of the boiler proper, having 401 2¼-in. flues, 21 ft. long, and a heating surface of 4,941 sq. ft. These flues terminate in a combustion chamber 54 in. long, occupying the full section of the boiler in front of which is a feed water heater. The tubes in this feed water heater are of the same number and diameter as in the boiler and are set in alignment with the boiler tubes. They terminate in a front end of the usual form. The combustion chamber is provided with a man hole, so that the tube ends therein are readily accessible and a further provision for facilitating repairs is made by separating the boiler shell at the rear end of the combustion chamber. This joint is made by riveting a heavy ring to each boiler section, which rings are butted with a V-shaped fit and secured together by 42 1¼-in. bolts.

Two non-lifting injectors discharge on either side into the feed water heater, which is kept constantly filled with water. The boiler feed passes out from the top of this chamber and is delivered into the main barrel through two checks, one on either side, located just back of the front tube sheet.

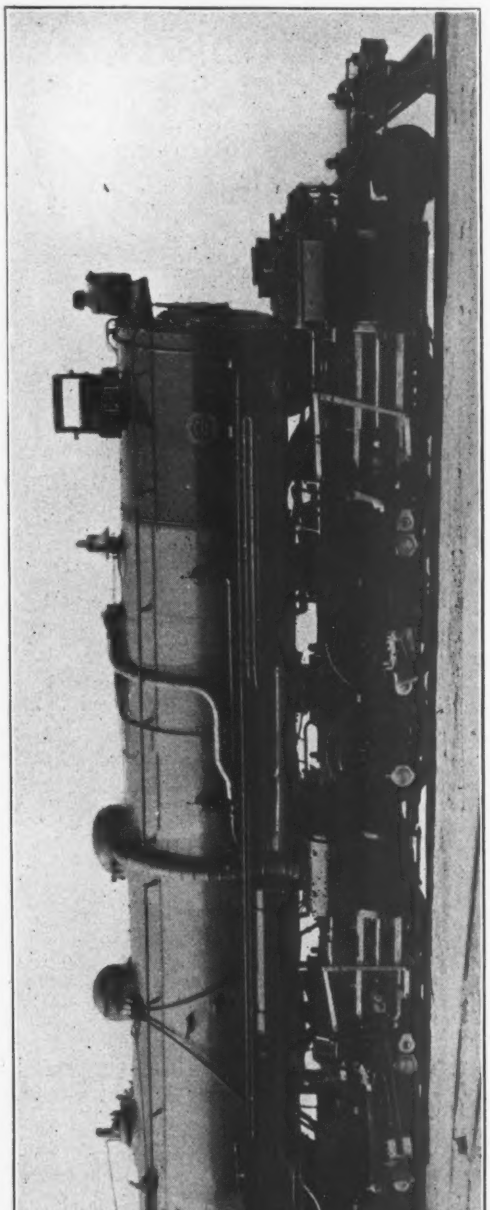
A Baldwin type of superheater is placed in the front end and connected in the piping system between the high and low pressure cylinders, thus forming, in this case, a reheater. It will no doubt be found that the addition of heat to the steam at this point will prove to be of great advantage from an operating standpoint as well as thermodynamically.

The waist-bearer under the combustion chamber is bolted in place, while the front waist-bearer and the high-pressure cylinder saddle, are riveted to the shell. The longitudinal seams in the barrel are placed on the top center line, and have diamond welt strips inside. Flexible staybolts are liberally used in the sides, back and throat of the firebox, while the crown sheet is stayed with tee irons hung on expansion links, in accordance with Associated Lines practice.

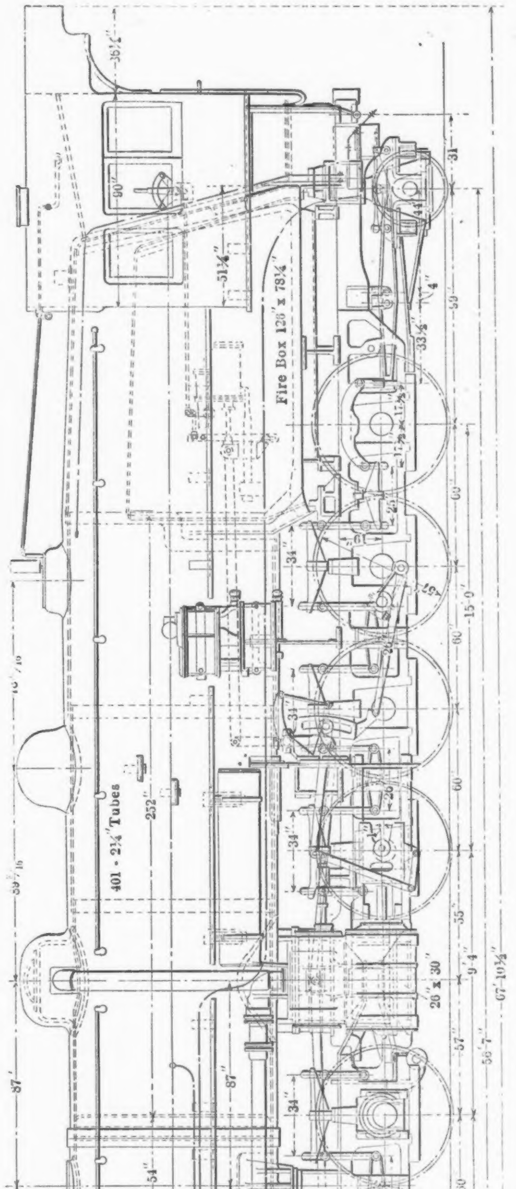
The dome, which is of cast steel, is placed immediately above the high-pressure cylinders, and the arrangement of the throttle and live steam pipes is similar to that used on heavy articulated locomotives previously built by this company. The exhaust from the high-pressure cylinders passes into two pipes which lead to the reheater in the front end. These pipes are of steel, and each is fitted, at the back end, with a slip joint made tight with a packed gland. The steam enters the reheater at the front end of the device, and passes successively through six groups of tubes. It then enters a T-connection, from which it is conveyed to the low-pressure cylinders through a single pipe having a ball joint at each end and a slip joint in the middle. Each low-pressure cylinder is cast separately, and is bolted to a large steel box casting, which is suitably cored out to convey the steam from the receiver pipe to a pair of short elbow pipes, making final connection with the low-pressure steam chests. The distribution is here controlled by 15-inch piston valves which are duplicates of those used on the high-pressure cylinders. The final exhaust passes out through the front of each casting, into a T-connection, which communicates with a flexible pipe leading to the smoke-box. The slip joint in this pipe is made tight by means of snap rings and leakage grooves. At the smoke-box end, the ball joint is fitted with a coiled spring which holds the pipe against its seat. The valves for both the high and low-pressure engines are set with a travel of 5½ inches and a lead of 5-16 inch. The steam lap is 1 inch, and the exhaust clearance 1-16 inch. Reversing is effected by the Raggonet power gear,* which is operated by compressed air and is self-locking. The gear is directly connected to the high-pressure reverse shaft. The reach rod connection to the low-pressure reverse shaft, is placed on the center line of the engine, and is fitted with a universal joint located immediately above the articulated frame connection. The joint is guided between the inner walls of the high-pressure cylinder saddle. In this way the reversing connections are simplified, and when the engine is on a curve the angular position of the reach rod has practically no effect on the forward valve motion. This arrangement has been made the subject of a patent.

One of the locomotives is equipped with vanadium steel frames, and the other with frames of carbon steel. The connection between the frames is single, and is effected by a cast steel radius-bar which also constitutes a most substantial tie for the rear end of the front frames. The fulcrum pin is 7 inches in diameter;

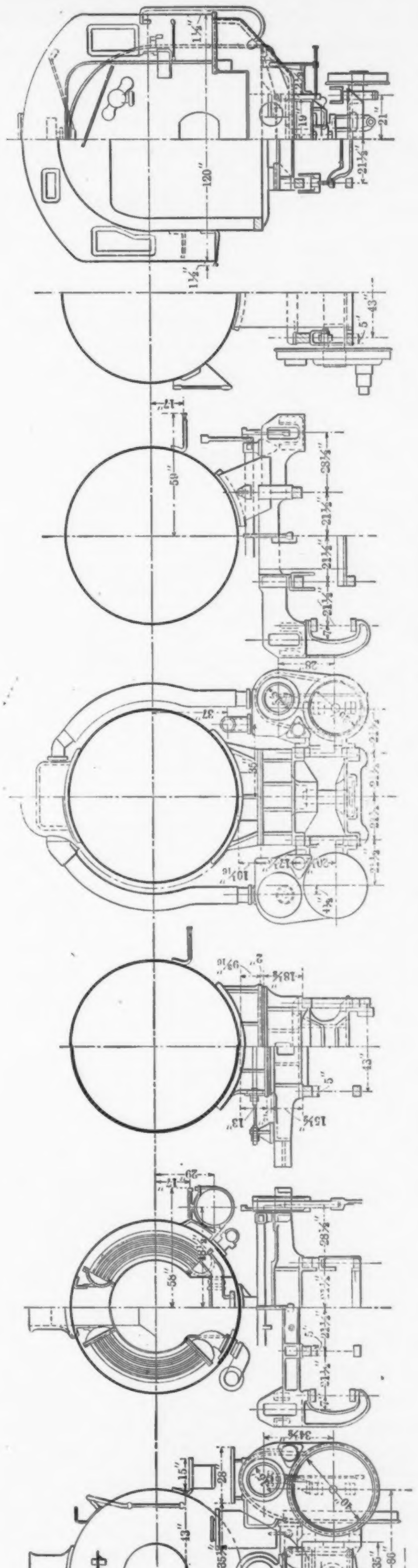
* See AMERICAN ENGINEER, July, 1908, page 260.



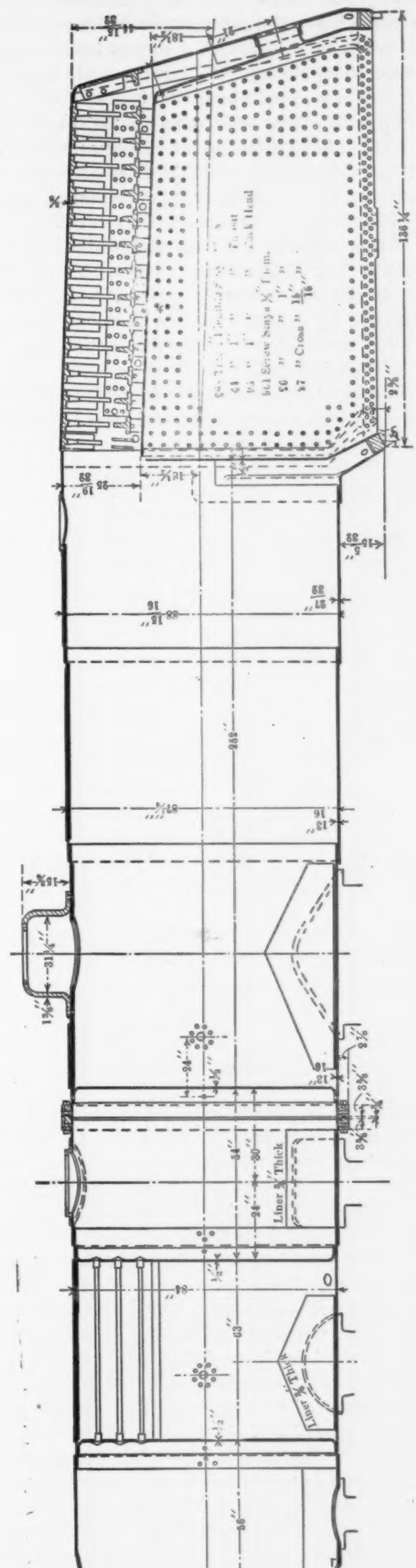
GENERAL VIEW OF THE LARGEST LOCOMOTIVE IN THE WORLD—SOUTHERN PACIFIC 2-8-8-2 TYPE.



ELEVATION OF MALLET ARTICULATED COMPOUND, 2-8-8-2 TYPE LOCOMOTIVE—SOUTHERN PACIFIC COMPANY.



END ELEVATION AND SECTIONS OF SOUTHERN PACIFIC 2-8-8-2 TYPE LOCOMOTIVE.



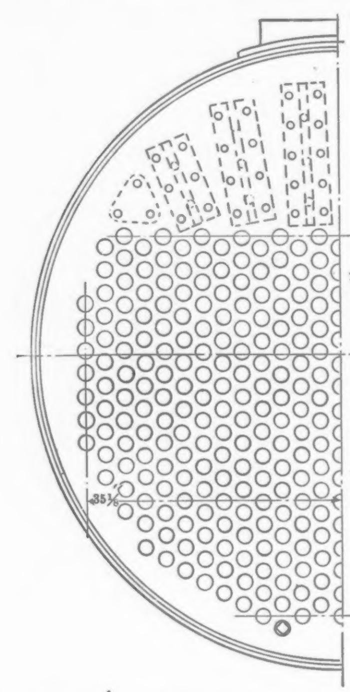
LONGITUDINAL SECTION OF BOILER AND FEED WATER HEATER—SOUTHERN PACIFIC 2-8-8-2 TYPE LOCOMOTIVE.

it is inserted from below, and held in place by a plate supported on a cast steel crosstie, which spans the bottom rails of the rear frames between the high-pressure cylinders. The weights on the two groups of wheels are equalized by contact between the front and rear frames, no equalizing bolts being used in this design.

The front frames are stopped immediately ahead of the leading driving pedestals, where they are securely bolted to a large steel box casting, previously mentioned, which supports the low-pressure cylinders. The cylinders are keyed at the front only. The bumper beam is of cast steel, 10 feet long, while the maximum width over the low-pressure cylinders is approximately 11 feet.

The boiler is supported, on the front frames by two bearings, both of which have their sliding surfaces normally in contact. The front bearing carries the centering springs, and the wear is taken, in each case, by a cast iron shoe 2 inches thick. Both bearings are fitted with clamps to keep the frames from falling away when the boiler is lifted.

This locomotive naturally embodies in its design many smaller details of interest which will be illustrated later. The cylinder



ELEVATION OF FRONT FLUE SHEET.

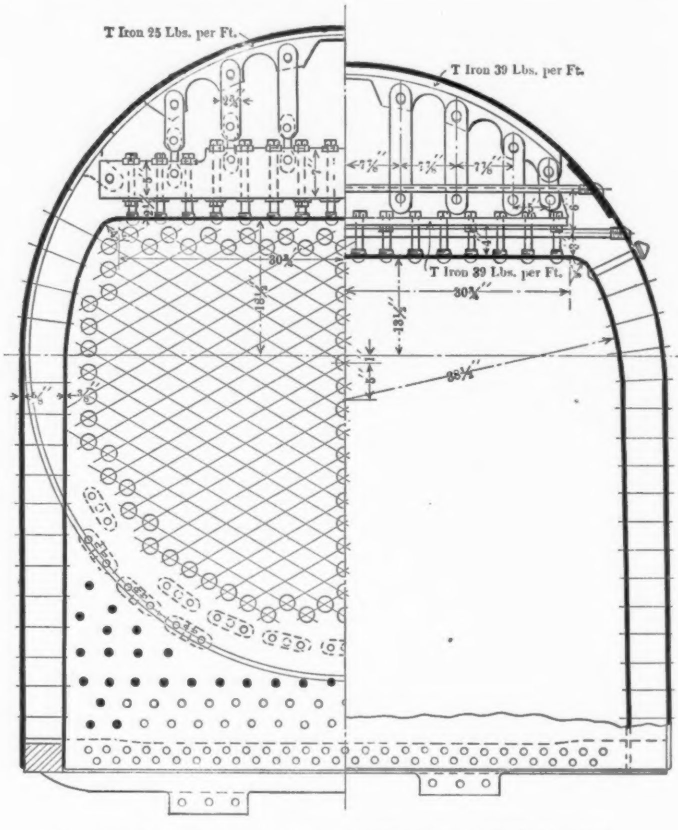
and steam chest heads are of cast steel, the low-pressure heads being dished and strongly ribbed. The low-pressure pistons are also dished; they have cast steel bodies, and the snap rings are carried by a cast iron ring which is bolted to the body, and widened at the bottom. The links for the low-pressure valve gear are placed outside the second pair of driving wheels, and are supported by cast steel bearers which span the distance between the guide yoke and the front waist bearer. The low-pressure valve stems are connected to long crossheads, which slide in brackets bolted to the top guide bars. The locomotive is readily separable, as the joint in the boiler is but a short distance ahead of the articulated frame connection, and all pipes which pass the joint are provided with unions. The separable feature has been tested and proved entirely feasible. Sand is delivered to the rear group of driving wheels from a box placed on top of the boiler, and to the front group from two boxes placed right and left ahead of the leading drivers. The high pressure cylinders are lubricated from the cab in the usual manner, while the low pressure are lubricated by means of a force feed pump driven from the forward valve motion. This arrangement avoids the use of flexible oil piping.

The tender is designed in accordance with Associated Lines standards, and is fitted with a 9,000 gallon water-bottom tank. The capacity for oil is 2,850 gallons.

The detail parts of this locomotive have, where possible, been designed in accordance with existing standards of the Associated Lines. The engine is practically equivalent, in weight and capacity, to two large consolidation type locomotives, and in spite of its great size, presents a pleasing and symmetrical appearance.

The general dimensions are given below:

GENERAL DATA.	
Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Oil
Tractive effort	94,640 lbs.
Weight in working order	425,900 lbs.
Weight on drivers	394,150 lbs.
Weight on leading truck	14,500 lbs.
Weight on trailing truck	17,250 lbs.
Weight of engine and tender in working order	596,000 lbs.
Wheel base, driving	39 ft. 4 in.
Wheel base, total	56 ft. 7 in.
Wheel base, engine and tender	83 ft. 6 in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.18
Total weight ÷ tractive effort	4.51
Tractive effort x diam. drivers ÷ heating surface	843.00
Total heating surface ÷ grate area	93.40
Firebox heating surface ÷ total heating surface, %	3.63
Weight on drivers ÷ total heating surface	61.00
Total weight ÷ total heating surface	67.00
Volume equiv. simple cylinders	28.84
Total heating surface ÷ vol. cylinders	220.00



SECTION THROUGH FIREBOX—SOUTHERN PACIFIC MALLET.

Grate area ÷ vol. cylinders	2.38
CYLINDERS.	
Kind	Compound
Diameter	26 & 40 in.
Stroke	30 in.
VALVES.	
Kind	Piston
Diameter	15 in.
Greatest travel	5½ in.
Outside lap	1 in.
Inside clearance	1/16 in.
Lead, constant	5/16 in.
WHEELS.	
Driving, diameter over tires	57 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	11 x 12 in.
Driving journals, others, diameter and length	10 x 12 in.
Engine truck wheels, diameter	30½ in.
Engine truck, journals	6 x 10 in.
Trailing truck wheels, diameter	30½ in.
Trailing truck, journals	6 x 10 in.
BOILER.	
Style	Straight
Working pressure	200 lbs.
Outside diameter of first ring	84 in.
Firebox, length and width	126 x 78¼ in.
Firebox plates, thickness	⅜ & ½ in.
Firebox, water space	5 in.
Tubes, number and outside diameter	401—2¼ in.
Tubes, length	21 ft.
Heating surface, tubes	4,941 sq. ft.
Heating surface, firebox	232 sq. ft.
Feed water heater tubes, number and diam.	401—2¼ in.
Feed water heater tubes, length	5 ft. 3 in.
Feed water heater, heating surface	1,220 sq. ft.

Heating surface, total	6,393 sq. ft.
Reheater heating surface	655 sq. ft.
Grate area	68.4 sq. ft.
Smokestack, height above rail	15 ft. 2½ in.
Center of boiler above rail	120 in.
TENDER.	
Wheels, diameter	33¼ in.
Journals, diameter and length	6 x 11 in.
Water capacity	9,000 gals.
Oil capacity	2,850 gals.

RAILROAD MACHINE SHOP PRACTICE.

II.—DRIVING BOXES.

George J. Burns.

If any one class of locomotive repair work more than another justifies a study of comparative costs and results it is locomotive driving boxes. With but few exceptions each shop is strenuous in claiming that its own particular practice is the best. If the cost happens to be high it is contended that the additional expense is more than offset by superior efficiency. If the job is somewhat roughly done it is claimed that it is all sufficient for its purpose, and that unnecessary exactness is extravagant. The object of this article will, therefore, be to lay before the reader comparative processes and costs and not to undertake to advise which practice should be adopted. The cost and time for doing the same work with the same class of tools in different shops varies so greatly as to justify any one in doubting the accuracy of some of the observations. To simplify comparisons, cast steel boxes only will be considered.

Facing—Exclusive of Recess or Channel on Hub Side.—This work is done on planers, milling machines, boring mills, shapers, and to a limited extent on lathes. The practice is determined by the character of work and by the equipment of the shop. If the recess on the hub side is machined, the facing, on that side at least, can be done most economically on a boring mill. The shortest facing time observed was 30 minutes per box on a powerful milling machine. That time is easily possible on a modern planer. The longest time observed was a three hour job on a planer.

Recess on Hub Side.—The practice is so varied that comparisons are almost out of the question. In some shops the recesses are machined and in others they are dovetailed in addition with more or less elaboration. This was particularly observed in a shop where a brass plate was used instead of casting babbitt on the box. The tendency seems to be in the direction of not machining the recess. The contention is that not only is the machining expensive, requiring the facing to be done on a boring mill, but that the rough surface holds the babbitt better than the machined surface. In most shops the babbit is held in place by tapping brass plugs into the box. In some shops the plugs are staggered with view of securing a continuous brass bearing. The best practice for holding the babbitt seems to be to have the sides of the recess slightly eccentric with each other.

Crown or Shell Fit.—This work is done on planers, shapers and slotters. The planer seems to give the poorest efficiency, and a special draw stroke shaper the best. The wide variation in time of doing this work on the same class of tools emphasizes the necessity of profiting by comparison. The shortest time was one hour per box, and the longest time was 7½ hours per box.

Cellar Fit.—In some shops the legs are machined at the time the crown fit is made and any variation resulting from pressing in the brass is allowed for by fitting the cellar to caliper measurement. In other shops the legs of the box are machined to standard after the brasses are pressed in; sometimes they are simply surfaced and squared, each cellar being fitted to its box.

The practice in coring the legs of the box also varies greatly. Some roads do not core at all, deeming the support the full width of the leg on the cellar to be of more importance than the shop time saved by coring. Some legs are cored in the center, leaving a band on four sides. The advantage of such coring is doubtful, as in machining the tool is required to make full stroke and where the coring is shallow there is a liability, as noted in one shop, that the tool will run in the scale. The most common practice in coring the leg is to core across, leaving a band at the top and the bottom. On some roads the coring is up and down, leaving a band at each side. That form is of doubtful advantage, especially as the coring is crosswise on most cellars. On some roads there is no uniformity as to coring, all forms being more or less in use. The time for machining the legs for the cellar fit varies all the way from 45 minutes to 3 hours per box.

Shoe and Wedge Fit.—The most universal practice is to back off or taper the side of the shoe and wedge fit. On one road, at least, the sides are not tapered and equally good results are claimed to be secured. The shoe and wedge fit is made on planers, milling machines, and shapers. The shortest time observed was one hour per box on a milling machine. That time ought to be possible on a modern planer. The longest time observed was four hours; the usual time was about two hours—all taper work.

Replaning.—Here again there is such a wide range in time and such a wide variation in practice that attempts at comparison are confusing. If the least expensive practices are sufficient, the most expensive are inexcusable.

Most roads in replaning follow the taper of the sides. Some few roads replane straight, relying upon the fillet to compensate for the taper. The practice seems to be tending toward one tool work, roughing and finishing in one cut.

Is there a necessity for a brass bearing between the box and the shoes and wedges? One important road, at least, does not deem such a bearing a necessity. The mechanical department, after carefully observing results and considering all arguments pro and con, contend that the advantage of the brass bearing is not commensurate with its cost. They claim that the brass bearing offers no advantage whatever, providing the surfaces are kept reasonably well lubricated. Other roads claim that the brass bearing is necessary and that lubrication will not offset it.

In shops where a brass bearing is deemed necessary, the following practices have been observed:

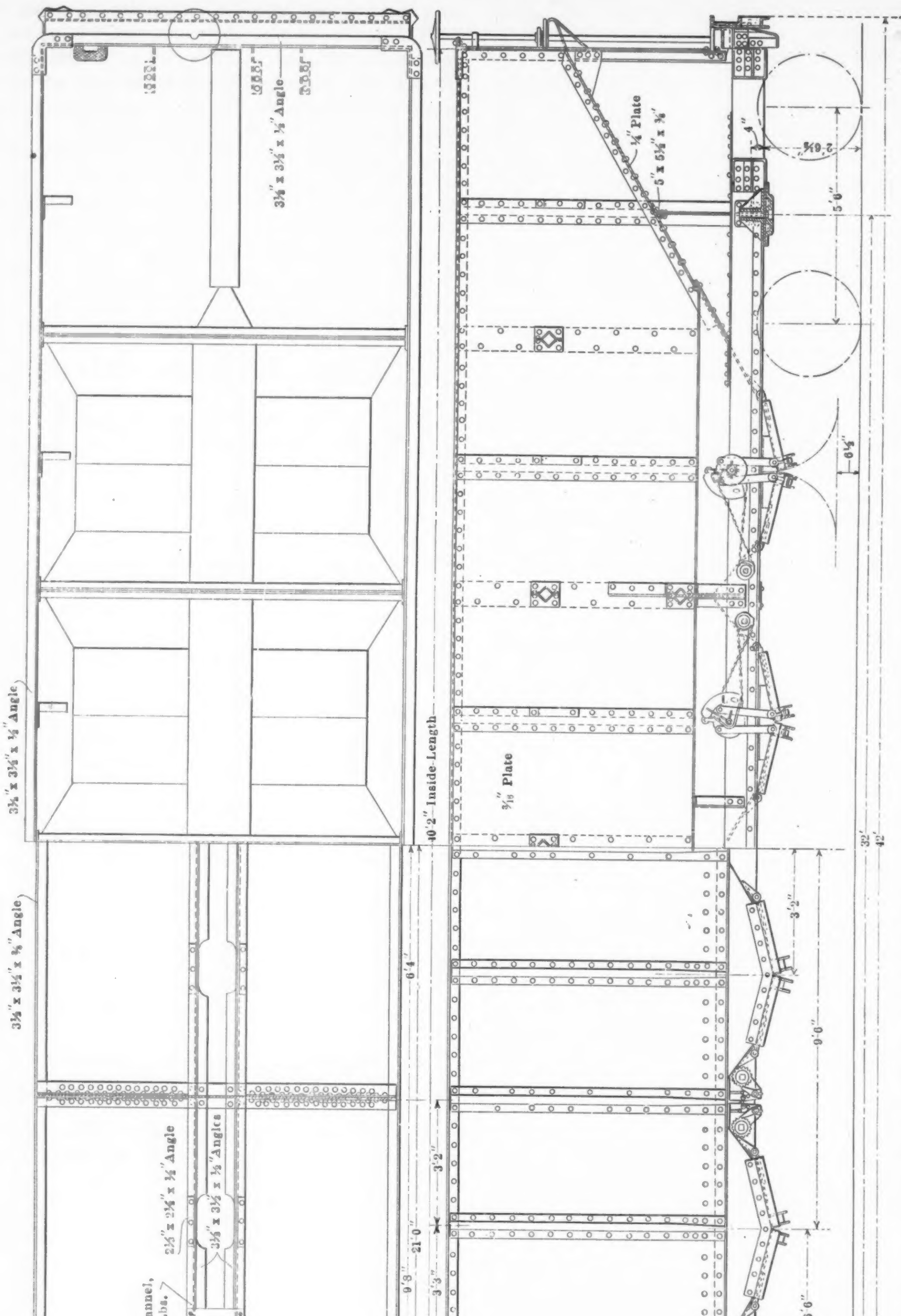
1. Brass shoes and wedges.
2. Shoes and wedges with brass facing.
3. Brass liners on first repairs.
4. Brass liners when boxes become so thin they cannot be safely further replaned.
5. Most brass liners are fitted and riveted to the box.
6. On some roads the brass liner is cast in position in the box.

The shortest time observed for replaning was 25 minutes per box, and the longest 1½ hours per box. The usual time was about one hour.

Power Plant Efficiency.—H. G. Stott, Mem. of the Am. Soc. of Mech. Engrs., estimates the average heat distribution in the power house as shown in the following table:

	Per cent.	Per cent.
Heat in the coal		100
Loss in ashes	2.4	
Loss in stack	22.7	
Loss from boiler radiation and leakage	8.0	
Returned by feed water heater		3.1
Returned by economizer		6.8
Loss in pipe radiation	0.2	
Delivered to circulator	1.6	
Delivered to boiler feeder	1.4	
Leakage and high pressure drips	1.1	
Heating	0.2	
Loss in engine friction	0.8	
Delivered to small auxiliaries	0.4	
To house auxiliaries	0.2	
Radiation from engine	0.2	
Rejected to condenser	60.1	
Electrical losses	0.3	
Totals	99.6	109.9
Delivered to bus-bar	10.3	

We may assume that with a good steam generating station we convert but ten per cent. of the heat stored in the coal into electricity, on the bus-bars. Further losses due to distribution and conversion, in various ways, to light and power occur so that we get but little of the potential energy provided for our use by a wise and beneficent nature. Surely, if our ecclesiastical brethren maintain that the storage of coal is a manifestation of Divine Providence, the present inventions for utilizing it must have emanated from his Satanic Majesty.—*From President M. L. Holman's address before the A. S. M. E.*



FOUR-HOPPER STEEL COKE CAR—100,000 POUNDS CAPACITY—PENNSYLVANIA RAILROAD.

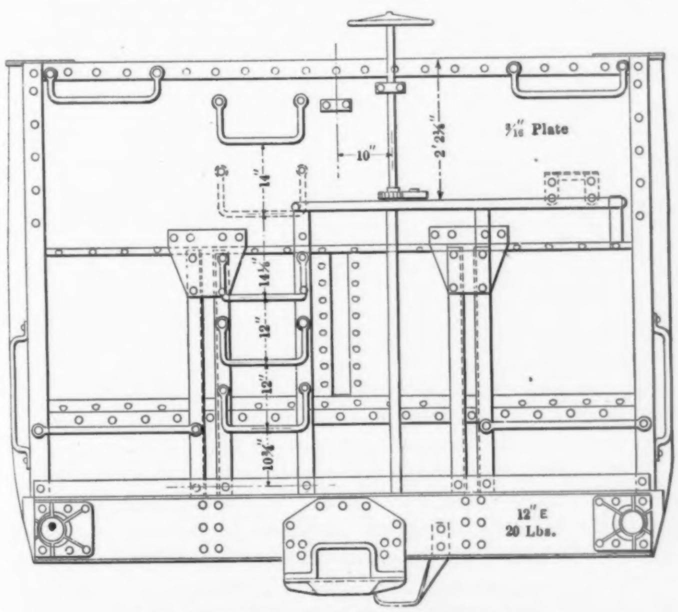
FOUR-HOPPER STEEL COKE CAR

PENNSYLVANIA RAILROAD.

The standard equipment * of the Pennsylvania Railroad for transporting coke has been the classes Gpa, Gsa and Gsd cars, which were fully illustrated and described in this journal October, 1905, page 359, and January, 1906, page 11. Recently, however, in considering the ordering of more equipment of this type a new design, having four-hoppers, which is entirely self-clearing and has a capacity of 2,794 cu. ft., or 85,000 lbs. of coke, has been developed. This is known as class H-21.

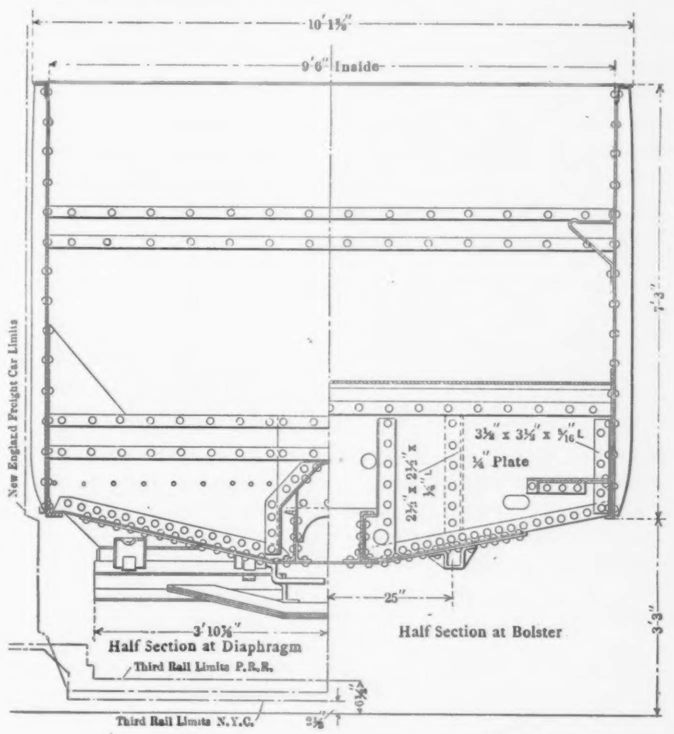
The features of this car are, in many particulars, very similar to the standard Gla steel hopper car, which was illustrated and described on page 148 of the May, 1905, issue of this journal. The same principles of design hold in both cars, the principal difference being in the arrangement and construction of the hoppers and their operating gear.

Structural steel members and plates are used almost exclusively, the side stakes, cross braces and diagonal braces at end sills being practically the only pressed forms. Two 10 in., 25 lb., channels extending continuously from end sill to end sill, reinforced by 3½ x 3½ x ½ in. angles on the lower edges between the bolsters, and a cover plate through and for a short distance on either side of the bolster, form the center sill construction. There are no side sills between the bolsters, the 8 in. channels reaching only from the end sills to the bolsters. The design utilizes the strength of the sides, which are built of 3/16 in. plates reinforced by pressed steel stakes, spaced about 3 ft. 2 in. apart, in a vertical direction and by the 3½ x 3½ x ½ in. angles at the top and 3½ x 3½ x ⅜ in. angles at the bottom, for load carrying. The body bolster, of the single plate type, is practically identical with that in the Gla car and consists of a ¼ in. plate set vertically and secured to the ¼ in. floor plate and the side plates by angles; also reinforced by angles at the bottom edge. The end sill is somewhat heavier than on the Gla car, being formed of a 12 in., 20 lb., channel. The diagonal braces are located between the ends of the bolster and the junction of the center sill and end sill, the same as in the former design. Because of the great length of this car another cross support or diaphragm, of construction quite similar to that of the bolster, is located at either end, 9 ft. 8 in. inside the bolster. It is also of ¼ in. plate, being secured at the top to a box type of cross brace, formed in two sections and secured to the side sheets. The sides are stiffened by a gusset plate at these points, as is shown in the illustration. The cross braces or side stiffeners, of which there are five in addition to the two forming part of the diaphragms just mentioned, all being of the same type, are placed about ⅓ of the distance down from the top of the sides and located at every second side stake.



END ELEVATION—FOUR-HOPPER COKE CAR.

The hopper doors are double and formed in pairs, one set on either side of the center sill. All four doors, on one hopper, however, are operated by one device. The doors are of ¼" pressed steel, hinged on the outer edges and provide an opening 3 ft. x 3 ft. 6 in. on each side of the center sills for each hopper or a total opening, with all doors released, of 84 sq. ft. in the bottom of the car. The doors when swung full open have a clearance of 6½ in. from the top of the rail.



SECTIONS OF FOUR-HOPPER COKE CAR.

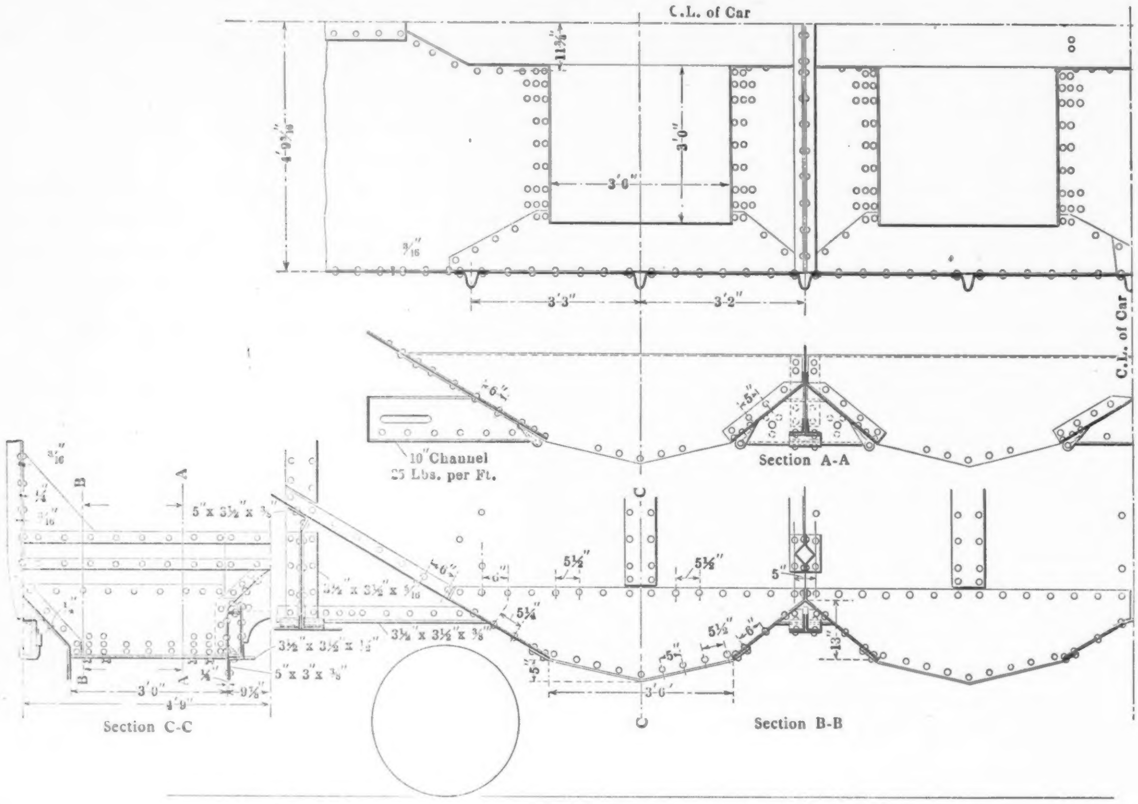
The illustrations show the construction of the hoppers and the door operating device very clearly. It was necessary to cut away the reinforcing channels on the bottom of the center sills at the points where the operating gear is located and a 5 x 3 x ⅜ in. angle is secured to the bottom of the center sill channels at these points. The ridge sheets which cover the center sills between the hopper openings are of ¼ in. plate and aid in giving stiffness to the sills. The door operating device is so constructed that when fully closed it is practically locked and requires a slight movement before it will open by gravity. As an additional safeguard a ratchet wheel and pawl are provided at each winding shaft, to prevent any possibility of the doors dropping by accident.

The trucks are of the Pennsylvania standard arch bar type for 100,000 lb. cars and have pressed steel bolsters, 33 in. wheels and 5½ x 10 in. journals.

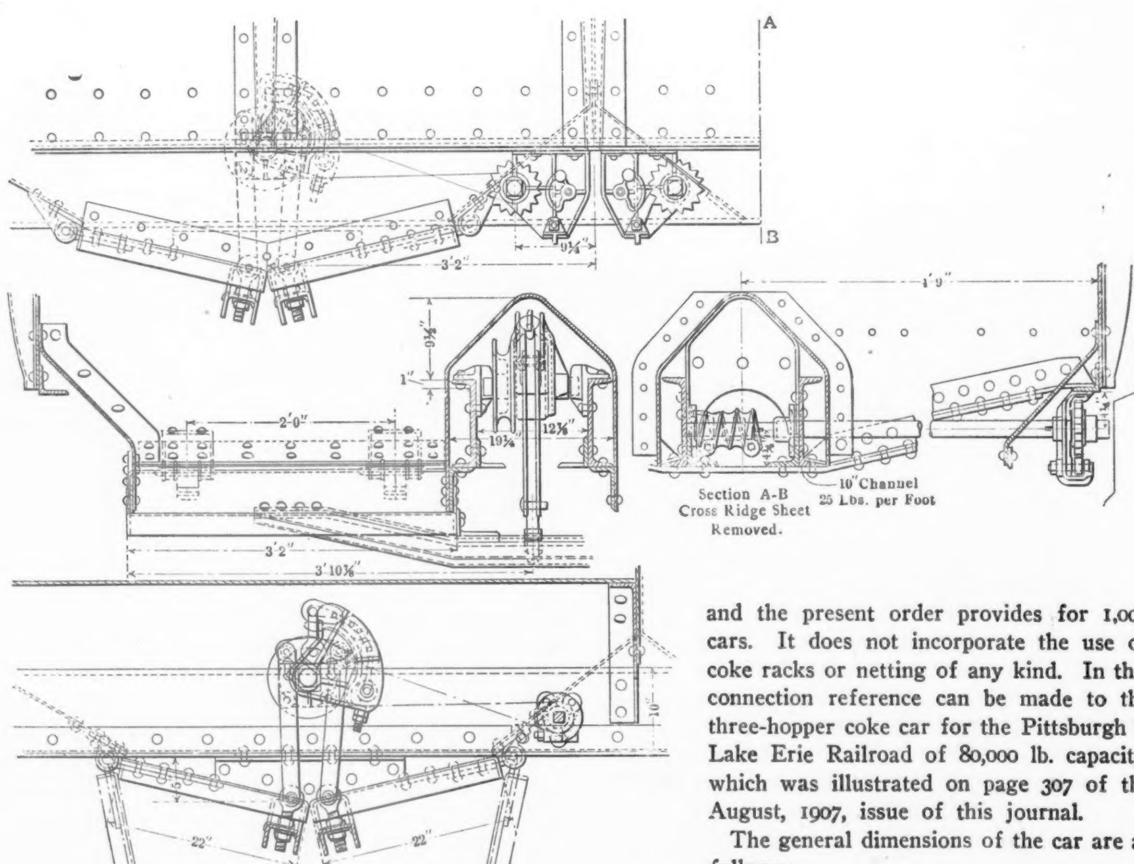
The draft gear arrangement provides for the use of Westinghouse friction draft gear, the lower flange of the end sill being cut away to accommodate the passage of the coupler shank; the sill is reinforced by a heavy steel casting at this point.

This is the first four-hopper coke car that has ever been built

* For the steel car equipment of the Pennsylvania Railroad reference can be made to the table on page 84 of the March, 1909, issue of this journal.



HOPPER DETAILS—FOUR-HOPPER STEEL COKE CAR, PENNSYLVANIA RAILROAD.



DETAILS SHOWING DOOR OPERATING DEVICE ON FOUR-HOPPER STEEL COKE CAR, PENNSYLVANIA RAILROAD.

and the present order provides for 1,000 cars. It does not incorporate the use of coke racks or netting of any kind. In this connection reference can be made to the three-hopper coke car for the Pittsburgh & Lake Erie Railroad of 80,000 lb. capacity, which was illustrated on page 307 of the August, 1907, issue of this journal.

The general dimensions of the car are as follows:

Length over end sills	42 ft.
Length inside	40 ft. 2 in.
Inside width	9 ft. 6 in.
Height from rail to top of sides	10 ft. 6 in.
Truck centers	32 ft.
Capacity in cu. ft.	2,794 cu. ft.
Capacity in lbs.	100,000 lbs.
Weight	54,900 lbs.

BUYING COAL ON A HEAT VALUE BASIS.

The plan inaugurated by the Government two years ago for the purchase of coal on the basis of its heating value has resulted in the delivery of a better grade of fuel without a corresponding increase in cost. At the present time, forty departmental buildings in Washington, the Panama Railroad, more than 300 public buildings throughout the United States, navy yards, and arsenals are buying their fuel supplies on specifications the prime element in which fixes the amount of ash and moisture. Premiums are paid for any decrease of ash below 2 per cent. from the standard at a rate $.01 per ton for each per cent. Deductions are made at an increasing rate for each per cent. of ash when it exceeds the standard established by 2 per cent.

Since the Government has been purchasing coal on the basis of its heating value a growing interest has been manifest on the part of manufacturers and the general public in this important subject, and a demand has been created for authentic information concerning the results accomplished. In response to this demand the results of the Government's purchases of coal under the heat value specifications for the fiscal year 1907-8 have been assembled in a bulletin just issued by the Survey in the hope of promoting a better understanding of this method of buying fuel. John Shober Burrows, the engineer in charge of this part of the fuel problem, has included in the bulletin a list of the contracts with abstracts of the specifications for the current fiscal year.

In explaining the nature of the specifications, Mr. Burrows says: "Government specifications are drawn with a view to the consideration of price and quality. For manufactured articles and materials of constant and uniform quality they generally can be reduced to a clear statement of what is desired. For coal, however, the variation in character makes this impracticable.

"This lack of uniformity is the feature recognized and provided for in the coal specifications prepared by the Geological Survey. Under these specifications, bidders are requested to quote prices on the various sizes of anthracite, a definite standard of quality being specified for each size, and to furnish the standard of quality with price for bituminous coal offered. Awards are then made to the lowest responsible bidder for anthracite and to the bidder offering the best bituminous coal for the lowest price. The specifications become part of the contract, and the standards of quality form the basis of payment for coal delivered during the life of the contract. For coal delivered, which is of better quality than the standard, the contractor is paid a bonus proportional to the increased value of the coal. For deliveries of coal of poorer quality than the standard, deductions are made from the contract price proportional to the decreased value of the coal. The actual quality and value of coal delivered is determined by analysis and test of representative samples taken in a specified manner by agents of the Government and analyzed in the Government fuel-testing laboratory at Washington.

"The advantages of buying coal on specifications are explained as follows: Bidders are placed on a strictly competitive basis as regards quality as well as price. This simplifies the selection of the most desirable bid and minimizes controversy and criticism in making awards. The field for both the Government and dealers is broadened, as trade names are ignored and comparatively unknown coals offered by responsible bidders may be accepted without detriment to the Government. The Government is insured against the delivery of poor and dirty coal, and is saved from disputes arising from condemnation based on the usual visual inspection. Experience with the old form of Government contract shows that it is not always expedient to reject poor coal, because of the difficulty, delay, and cost of removal. Under the present system rejectable coal may be accepted at a greatly reduced price. A definite basis for the cancellation of contract is provided. The constant inspection and analysis of the coal delivered furnishes a check on the practical results obtained in burning the coal."

COST OF STEEL PASSENGER CARS.

In commenting on the cost of all-steel passenger cars, at a recent meeting of the Central Railway Club, Charles Lindstrom, chief engineer of the Pressed Steel Car Company, spoke as follows: "The cost of cars depends, to a great extent, on the number of cars in a given order, but it is doubtful if many prospective buyers of steel cars have any real idea of what this cost amounts to. I will give a few figures to illustrate, in a general way, the work required for an all-steel passenger coach."

Number of drawings and tracings	340
Cost of drawings and tracings	$3,000 to $5,000
Number of blue prints issued to shops and manufacturers	8,000
Number of bills of material; 50 lines on each bill	44
Number of requisitions for material	257
Number of different items ordered from purchasing agent	1,702
Number of bolts of various diameters and lengths	2,700
Number of screws of various diameters and lengths	4,200
Number of rivets of various diameters and lengths	31,200
Number of pounds of castings for dies	150,000
Time required to prepare drawings, bills of material, shop instructions, etc.	3 to 6 months

"To further illustrate what the cost of a slight change in the construction of a car will amount to, I may say that the dies for making the end deck plates for a car weigh about 25,000 lbs. and cost about $1,000, and that the dies for making side posts weigh about 8,500 lbs. and cost about $450. The actual cost of pressing any one of these shapes does not exceed $1 each. This data, I believe, will give a fair idea of the very great expense involved in producing steel cars, and is referred to with the hope that prospective purchasers of such cars will look over the field and ascertain what cars have already been built, and are in service, and if it is desired to have sample cars built, select one of these types from which two or three cars may be built at moderate cost instead of submitting to manufacturers of cars drawings of their standard wooden cars with request for bids on one or two steel cars of each type for experimental purposes, for it can readily be seen that, if the so-called 'over-head' charges for getting up designs of steel cars is in approximate proportion as enumerated above (and while it is true that such expenses cannot be charged to a few sample cars as it makes such cars absolutely prohibitive to customers, still the cost is there and has to be paid), it means that the over-head charges on passenger cars will be greater than necessary.

"If sample cars of existing design are ordered and tried out, when the time comes that the purchaser is ready to go into the market for a larger number of steel cars a particular design, suitable to the requirements of the road, may be evolved without danger of prohibitive cost, even if entirely new plans, dies, templates and other requirements would have to be made, but it may not be out of place to mention here that changes should not be made in the design of cars merely in order to be different from some one else, or for the purpose of introducing some new ideas which may be just as good, but perhaps not better than what are already in use; changes should only be made when the service actually demands, in order to reduce the cost of the cars to the purchaser. When standard designs for steel cars are once adopted, the cost of such cars will not be much, if any, higher than wooden cars of the same seating capacity and including the same specialties."

PROPER CARE OF LEATHER BELTS.—In the average machine shop the writer is prepared to say that for more than half of the machines the belt drive can still be used with greater economy and with more satisfactory results than the electric drive; only on the assumption, however, that the belting is systematically cared for. The most serious objection to the belt drive as generally used is the loss of time due to interruption to manufacture when retightening and repairing and to the loss of driving power and consequent falling off in output, when the belt is allowed to run too slack. Belts can be tightened and repaired at regular intervals after working hours with the use of spring-balance belt-clamps to get the right tension, causing thus practically no interruption to manufacture.—*Fred W. Taylor before the A. S. M. E.*

A NEW DEPARTURE IN FLEXIBLE STAY-BOLTS.*

H. V. WILLE.

There is practically no literature on the subject of stay-bolts, and this is particularly true of flexible stay-bolts. The increasing size and pressure of boilers make this subject of vital importance to railroads and to those responsible for the management of that type of boiler in which the firebox is stayed by a large number of bolts.

The boiler of the consolidation locomotive, now the prevailing type in freight service, contains about 1,000 bolts less than 8 in. long and about 300 of greater length. The large types of Mallet compound locomotives now meeting with much favor have a much larger number, there being 1,250 short and 300 long bolts in locomotives of this class recently constructel.

In recent years some form of flexible stay-bolt, that is, one having a movable joint, has been very extensively used in the breaking zone of locomotive boilers, but their high cost and the difficulty of applying them, their rigidity due to accumulation of rust and scale and the fact that their use throws an additional service on the adjacent bolts because of lost motion have militated against their more general use.

It is well known that stay-bolts fail, not because of the tensional loads upon them, but from flexural stresses induced by the vibration resulting from the greater expansion of the firebox sheets than of the outside sheets, but notwithstanding the general acceptance of this theory, engineers have designed stay-bolts solely with respect to the tensional loads. It is quite general practice, it is true, to recess the bolts below the base of the thread, and this has effected a slight reduction in the fiber stress, but practically no effort has been made to design a bolt to meet the flexural stresses or even to calculate their magnitude. This is surprising in view of the simplicity of the calculations to which the ordinary formulae for flexure apply.

Let

F = fiber stress.
E = modulus of elasticity.
I = moment of inertia.
D = diameter.
N = deflection.
L = length.
W = load.

We then have

$$W = \frac{2FI}{DL};\ N = \frac{WL^3}{3EI}.$$

Now substituting

$$N = \frac{2FL^2}{3ED};\ F = \frac{3EDN}{2L^2}.$$

This formula shows that the stress increases in direct proportion to the diameter and decreases as the square of the distance between the sheets.

The application of the formula to service conditions gives the following stresses:

Conditions: Bolt spacing, 4 ins. c. to c.
Assumed expansion, 4/100-in.
Length of bolt, 6 ins.

Type.	Diameter of Bolt.	Flexural Stress.
Iron	1⅛ in.	51,500
Iron	1 in.	45,000
Iron	⅞ in.	39,400
Spring steel	1 in. ends, 7/16 in. stem	19,700

Iron is universally employed in the manufacture of these bolts and it is not good practice to exceed a fiber stress of 12,000 lbs. per sq. in. It is apparent that stay-bolts in the zone which meets the expansion of the sheets are stressed above the elastic limit and must necessarily fail from fatigue. Fractures always originate at the outside sheet at the point where the bending moment due to the movement of the furnace sheets is greatest.

The fractures are in detail, usually starting from the base of a thread and gradually extending inward. Manufacturers of stay-bolt material have endeavored to minimize failures and to meet the unusual conditions of an iron stressed beyond its elastic limit by the supply of specially piled iron arranged with a view to breaking up the extension of the initial fracture. For this reason iron piled with a central section of small bars and an envelope of flat plates has met with much success for this class of service. In a further effort to secure an iron specially adapted to this class of work various forms of shock, vibratory and fatigue tests have been imposed. No design has yet been produced, however, which permits the employment of material of elastic limit sufficiently high to resist the flexural stresses, although a large class of material particularly adapted to the purpose is available.

It is obvious that the remedy does not lie in the use of a slow-breaking material but in the employment of material of sufficiently high elastic limit to meet the conditions of service. It is also possible to reduce the diameter of the bolt greatly by the use of such a material, thus proportionately reducing the fiber stress in flexure.

Stay-bolt material, however, must possess sufficient ductility to enable the ends to be readily hammered over to make a steam-tight joint and to afford additional security against pulling through the sheets. To meet these conditions the bolt illustrated in Fig. 1 has been designed. The stem is of the same grade of

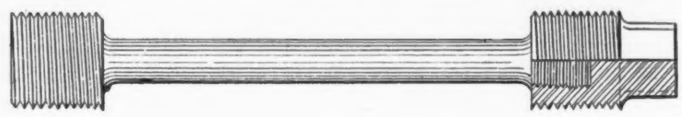


FIG. 1.

steel as that used in the manufacture of springs. It is oil-tempered and will safely stand a fiber stress of 100,000 lbs. per sq. in. Its high elastic limit makes it possible to reduce the diameter to ⅜ or 7/16 in. or even less. The ends are of soft steel, and it is thus possible to apply and head up the bolt in the usual manner. Fig. 2 shows this type of bolt in comparison with the regular design.

The employment of a stem of the diameter indicated reduces the fiber stress in flexure to less than one-half that in the ordinary type of bolt and it is of material capable of being stressed to a high degree. It has hitherto been impossible to employ in stay-bolts any of the steels containing chromium, nickel, vanadium or other metaloid possessing properties especially adapted to this class of work, but these steels can readily be used in the stem of the bolt described.

The stem of the bolt can be flexibly secured to the end in one of the customary ways, but the flexibility of the bolt does not depend upon a flexible connection. A type of bolt with a relatively inflexible connection, usually one in which the stem screwed into the ends with a running fit, met with the most favorable consideration. Such a bolt is flexible as a spring is flexible, in that it can be deflected to meet the requirements of service without exceeding the elastic limit. In fact the stem may be of a

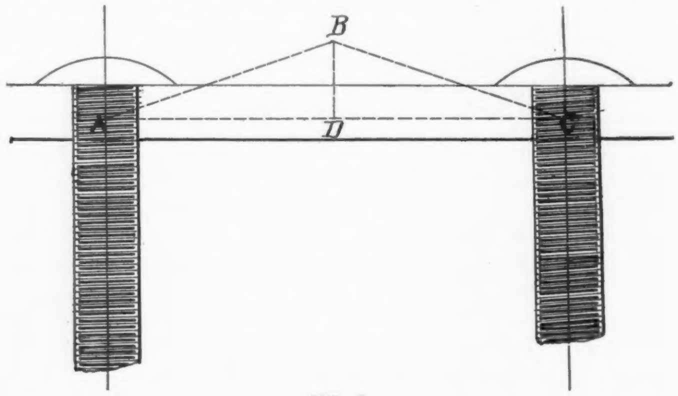


FIG. 3.

number of pieces, either of plates or small rods, thus increasing its flexibility.

The actual breaking strength of the bolt sizes ordinarily employed is shown in the accompanying table. These bolts were recessed to the base of the thread and tested in the same form as that in which they are employed in the service. For comparison, the approximate weights of bolts of the usual length are also given. These weights are for bolts over the entire length

* To be presented before the American Society of Mechanical Engineers.

including the squared ends for screwing the bolts into the sheets.

ACTUAL BREAKING STRENGTH OF STAY-BOLTS.

Type.	Nominal Diameter.	Actual Breaking Strength in lbs.	Weight.	Vibrations.
Iron	1-in.	32,500	20 oz.	6,000
Iron	⅞-in.	24,500	15 oz.	5,200
Spring steel stem..	1-in. ends 7/16 in. stem	32,000	10 oz.	500,000

The vibrating test was made by clamping one end of the bolt in a machine and revolving the other end through a radius of 3/32-in., the specimen being 6 ins. long from the end of the right head to the center of the rotating head. A tensional load of 4,000 lbs. was also applied to the bolts. The best grades of iron bolts break on being subjected to from 5,000 to 6,000 rotations, whereas the spring steel bolts were vibrated 500,000 times without failure, and on some of them the test was continued without failure to 1,000,000 vibrations. These tests demonstrated that the bolt is not stressed beyond the elastic limit under these severe conditions and that the probability of its failure in less severe conditions is very remote.

The extent of the expansion work which can take place in the firebox of a boiler can readily be calculated.

Distance between stay-bolts, 4 ins.

Temperature of inside sheet, 400° F.

Temperature of outside sheet, 100° F.

Coefficient of expansion, 0.0000066.

Then the expansion between the two bolts will equal 0.0000066 $\times$ (400 — 100) $\times$ 4 = 0.0079, and each bolt will deflect 0.00395 in. It has been shown that this amount of deflection will stress the usual type of bolt beyond the elastic limit. In practice, however, one bolt may hold rigidly, throwing the entire deflection on the adjacent bolt, or neither bolt may deflect and the sheet will then buckle. Under this condition the neutral axis will assume the form *ABC* (Fig. 3) and the length *AB* will equal 2.00395 in. and the sheet will buckle to an extent, $BD = \sqrt{2.00395^2 - 2^2} = 0.125$ in. It is obvious that the repetition of a force sufficient to buckle a sheet ⅛-in. must ultimately lead to a crack in the furnace sheets. If, however, the bolt deflects, allowing the sheet to normally expand, the latter will be relieved of these extranous loads.

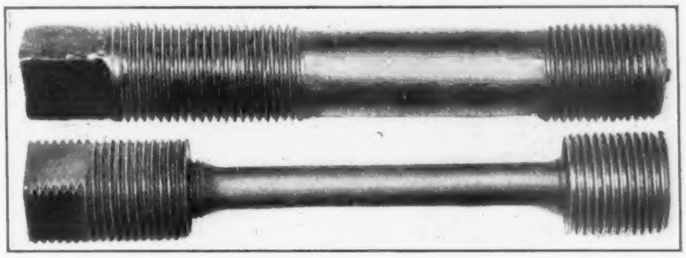


FIG. 2.

A bolt of sufficient flexibility to deflect under the forces following expansion, and of material which will not be stressed beyond the elastic limit in resisting these forces, will greatly assist in reducing the cost of boiler maintenance by eliminating broken stay-bolts and reducing the stresses in the furnace plates. If in addition the bolt has a smaller diameter the life of the furnace plates should be further increased, as such a bolt will interpose less obstruction to the circulation of the water in the water legs.

ALUMINUM A COMMERCIAL METAL.—The present price puts aluminum on a basis comparable with those of tin and copper. Weight for weight it is cheaper than tin, but bulk for bulk it is cheaper than either tin or copper. This level of price ought to stimulate greatly the consumption of aluminum, especially when the revival of general trade has gone a little farther. The producing capacity of Europe is increasing, while in the United States the Bradley patent will expire early in 1909, permitting free competition in the business here, just as there is now in Europe. Thus another year at least will put aluminum so that it can be classed, without the possibility of question, as an ordinary commercial metal.—*American Machinist.*

SPRING MEETING OF THE A. S. M. E.

The American Society of Mechanical Engineers will hold its spring meeting in Washington, D. C., May 4-7. Professional sessions will be held at which papers on the conveying of materials, gas power engineering, steam turbines, the specific volume of saturated steam, oil well pumping and various other subjects will be discussed.

At the reception, which will be held in the New Willard Hotel, an address of welcome will be made by the Hon. B. F. Macfarland, president of the Board of District Commissioners, with a response by Jesse M. Smith, president of the Society.

During the convention, President Taft will hold a reception for the members at the White House. The War Department will give a special exhibition drill of the United States troops at Fort Myer, to which the members and guests will be invited. At the same time, if the conditions are favorable, an ascension of a dirigible balloon will be made and probably also that of an aeroplane.

An address will be given by Rear-Admiral Melville, retired, past-president of the Society, and former Engineer-in-Chief of the Navy, the subject being "The Engineer in the Navy." This evening will be made the occasion for the presentation to the National Gallery of a portrait of Rear-Admiral Melville, presented by friends and admirers. It will be received for the National Gallery by Dr. C. D. Walcott, secretary of the Smithsonian Institution.

F. H. Newell, director of the Reclamation service, will deliver an illustrated address on "Home Making in the Arid Regions." Trips will be made to various points of interest about the city and a number of pleasurable excursions have been planned.

The papers to be presented are as follows: A Unique Belt Conveyor, by Ellis C. Soper; Automatic Feeders for Handling Material in Bulk, by C. Kemble Baldwin; A New Transmission Dynamometer, by Prof. Wm. H. Kenerson; Polishing Metals for Examination with the Microscope, by A. Kingsbury; Marine Producer Gas Power, by C. L. Straub; Operating System for a Small Producer Gas Power Plant, by C. W. Obert; A Method of Improving the Efficiency of Gas Engines, by T. E. Butterfield; Offsetting Cylinders in Single-Acting Engines, by Prof. T. M. Phetteplace; Small Steam Turbines, by Geo. A. Orrok; Oil Well Tests, by Edmund M. Ivens; Safety Valve Discussion; Specific Volume of Saturated Steam, by Prof. C. H. Peabody; Some Properties of Steam, by Prof. R. C. H. Heck, and A New Departure in Flexible Staybolts, by H. V. Wille.

THE OLDEST IRON SHIP IN THE WORLD.—The U. S. S. *Wolverine* (formerly U. S. S. *Michigan*) is the oldest iron ship in the world, according to Henry Penton in a paper before the Society of Naval Architects and Marine Engineers. This ship was built sixty-six years ago by the firm of Stackhouse & Tomlison, of Pittsburgh, and since that time has continued to be the whole United States navy on the Great Lakes, where treaty obligations restrict naval representation to one ship on each side. The firm who built the vessel has passed away, and probably few people are now living who even remember its launching; more probably none who took any part in its construction. Although it does not amount to much, judged by modern standards, it was a fine ship in its day and answers its purpose at the present time as well as then. It is stated that many naval officers who have risen to high rank and in their turn passed away have served on the old *Michigan.* On the navy list it is rated as an unarmored, unprotected cruiser, with a water line length of 165 ft.; beam, 27 ft.; displacement, 685 tons; indicated horsepower, 365; speed, 10.5 knots. The engines are of the simple inclined type, with two cylinders 36 in. in diameter and 8 ft. stroke. The original paddle wheels were 21 ft. 10 in. in diameter and each had 16 paddles or buckets. Much of our steam engineering knowledge is based upon the early experiments on expansion of steam, superheating, steam jacketing, condensation, etc., carried out on the *Michigan* by B. F. Isherwood, afterward engineer-in-chief, U. S. Navy.

ENGINEERING DATA—TUBES

From a hand-book on "The Mechanical Properties of Shelby Seamless Steel Tubing"; prepared by Prof. Reid T. Stewart. Published and copyrightea in 1908 by the National Tube Company of Pittsburgh, Pa., through whose courtesy we are enabled to present this data.

Table 9.—The cylindrical wall, as shown by Fig. 1, is subjected to both the circumferential stress f_t, and the longitudinal stress f_l, due to the action of the internal fluid pressure. Clavarino's formula is theoretically correct for this case, for tubes having walls of any thickness, so long as the stress upon the most strained fiber does not exceed the elastic limit of the material.

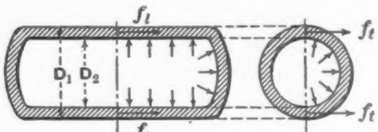


FIG. 1.

For steel tubes this formula is:

$$p=\frac{3(D_1^2-D_2^2)}{4D_1^2+D_2^2}f;\quad D_2=D_1\sqrt{\frac{3f-4p}{3f+p}};$$

$$D_1=D_2\sqrt{\frac{3f+p}{3f-4p}} \quad - - - - \quad (1)$$

Where D_1 = outside diameter of tube in inches.

D_2 = inside diameter of tube in inches.

f = working fiber stress of the material, pounds per square inch.

p = internal fluid pressure, pounds per square inch.

The fiber stress of 10,000 lbs. per sq. in. used in the table, corresponds to a factor of safety of about 5 for regular stock material with "finish anneal" and to about 2½ for the same material with "soft anneal." The safe working pressure for any other working fiber stress may be had by multiplying the value in the table by the desired fiber stress in pounds per square inch and then cutting off the four figures from the right of the resulting product.

Internal Fluid Pressures for Tubes with Closed Ends,* in Lbs. Per Sq. Inch Corresponding to a Fiber Stress of 10,000 Lbs. Per Sq. Inch in Wall

TABLE 9 — Reid T. Stewart and F. P. K., 1907. — Chkd. by W. F. F

Outside Diam. Inches	THICKNESS IN GAGE AND FRACTIONS OF AN INCH																
	22 BWG	20 BWG	18 BWG	1/16	3/32	1/8	5/32	3/16	7/32	1/4	5/16	3/8	1/2	5/8	3/4	7/8	1
1/2	1325	1648	2283	2877	4164	5294											
5/8	1063	1325	1840	2328	3408	4404											
3/4	888	1107	1541	1953	2877	3750	4560	5294									
7/8	762	951	1325	1681	2486	3258	3988	4670	5294								
1	668	833	1162	1475	2188	2877	3537	4164	4751	5294							
1 1/8	594	741	1034	1314	1953	2574	3174	3750	4298	4814							
1 1/4	535	668	932	1185	1763	2328	2877	3408	3917	4404	5294	6058					
1 3/8	.....	607	848	1079	1606	2124	2629	3120	3596	4053	4904	5658					
1 1/2	.....	557	778	990	1475	1953	2420	2877	3320	3750	4560	5294	6486				
1 3/4	.....	.....	.....	850	1268	1681	2087	2486	2877	3258	3988	4670	5854				
2	.....	.....	.....	745	1112	1475	1834	2188	2535	2877	3537	4164	5294	6226			
2 1/4	.....	.....	.....	662	990	1314	1635	1953	2266	2574	3174	3750	4814	5735			
2 1/2	.....	.....	.....	597	892	1185	1475	1763	2047	2328	2877	3408	4404	5294			
2 3/4	.....	.....	.....	543	812	1079	1344	1606	1867	2124	2629	3120	4053	4904			
3	.....	.....	.....	.....	745	990	1234	1475	1715	1953	2420	2877	3750	4560	5294	5940	6486
3 1/4	.....	.....	.....	.....	688	915	1140	1364	1586	1807	2242	2668	3487	4257	4966	5604	6163
3 1/2	.....	.....	.....	.....	639	850	1060	1268	1475	1681	2087	2486	3258	3988	4670	5294	5854
3 3/4	.....	.....	.....	.....	.....	794	990	1185	1379	1572	1953	2328	3056	3750	4404	5010	5564
4	.....	.....	.....	.....	.....	745	929	1112	1294	1475	1834	2188	2877	3537	4164	4751	5294
4 1/4	.....	.....	.....	.....	.....	.....	875	1047	1219	1390	1729	2064	2717	3346	3947	4514	5044
4 1/2	.....	.....	.....	.....	.....	.....	827	990	1153	1314	1635	1953	2574	3174	3750	4298	4814
4 3/4	.....	.....	.....	.....	.....	.....	783	938	1093	1246	1551	1853	2445	3018	3571	4099	4601
5	.....	.....	.....	.....	.....	.....	745	892	1039	1185	1475	1763	2328	2877	3408	3917	4404
5 1/4	.....	.....	.....	.....	.....	.....	677	812	945	1079	1344	1606	2124	2629	3120	3596	4053

*Calculated by Clavarino's formula

Table 10.—The cylindrical wall in this case, Fig. 2, is subjected to circumferential stress only, as, for example, in the case of cylinders for hydraulic plungers, shrunk tubular hoops and rings, and rings and drums subjected to centrifugal action due to rotation about their axes.

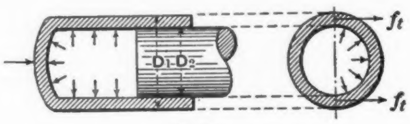


FIG. 2.

Birnie's formula is theoretically correct for this case, for tubes of any thickness, so long as the material is not stressed beyond the elastic limit. For steel tubes this formula is

$$p=\frac{3(D_1^2-D_2^2)}{4D_1^2+2D_2^2}f;\quad D_2=D_1\sqrt{\frac{3f-4p}{3f+2p}};$$

$$D_1=D_2\sqrt{\frac{3f+2p}{3f-4p}} \quad - - - - - \quad (3)$$

Internal Fluid Pressures for Tubes with Circumferential Stress Only,* in Lbs. Per Sq. In. Corresponding to a Fiber Stress of 10,000 Lbs. Per Sq. Inch in Wall

TABLE 10 — Reid T. Stewart and F. P. K., 1907. — Chkd. by W. F. F

Outside Diam. Inches	THICKNESS IN GAGE AND FRACTIONS OF AN INCH																
	22 BWG	20 BWG	18 BWG	1/16	3/32	1/8	5/32	3/16	7/32	1/4	5/16	3/8	1/2	5/8	3/4	7/8	1
1/2	1137	1426	2004	2561	3824	5000											
5/8	908	1137	1599	2045	3072	4068											
3/4	755	946	1330	1701	2561	3409	4228	5000									
7/8	646	809	1137	1455	2193	2927	3647	4342	5000								
1	565	707	994	1271	1916	2561	3199	3824	4427	5000							
1 1/8	502	628	882	1128	1701	2275	2846	3409	3960	4492							
1 1/4	451	565	793	1014	1529	2045	2561	3072	3576	4068	5000	5833					
1 3/8	.....	513	720	921	1388	1858	2327	2794	3256	3711	4586	5393					
1 1/2	.....	470	660	844	1271	1701	2132	2561	2988	3409	4228	5000	6316				
1 3/4	.....	.....	.....	722	1088	1455	1824	2193	2561	2927	3647	4342	5607				
2	.....	.....	.....	631	950	1271	1593	1916	2239	2561	3199	3824	5000	6022			
2 1/4	.....	.....	.....	560	844	1128	1414	1701	1988	2275	2846	3409	4492	5478			
2 1/2	.....	.....	.....	504	758	1014	1271	1529	1787	2045	2561	3072	4068	5000			
2 3/4	.....	.....	.....	458	689	921	1154	1388	1623	1858	2327	2794	3711	4586			
3	.....	.....	.....	.....	631	844	1057	1271	1486	1701	2132	2561	3409	4228	5000	5703	6316
3 1/4	.....	.....	.....	.....	582	778	975	1172	1370	1569	1966	2363	3150	3918	4651	5334	5950
3 1/2	.....	.....	.....	.....	540	722	904	1088	1271	1455	1824	2193	2927	3647	4342	5000	5607
3 3/4	.....	.....	.....	.....	.....	673	844	1014	1185	1357	1701	2045	2732	3409	4068	4698	5291
4	.....	.....	.....	.....	.....	631	790	950	1110	1271	1593	1916	2561	3199	3824	4427	5000
4 1/4	.....	.....	.....	.....	.....	.....	743	894	1044	1196	1499	1802	2410	3012	3605	4181	4734
4 1/2	.....	.....	.....	.....	.....	.....	702	844	986	1128	1414	1701	2275	2846	3409	3960	4492
4 3/4	.....	.....	.....	.....	.....	.....	664	799	933	1068	1339	1610	2154	2696	3232	3759	4270
5	.....	.....	.....	.....	.....	.....	631	758	886	1014	1271	1529	2045	2561	3072	3576	4068
5 1/4	.....	.....	.....	.....	.....	.....	573	689	805	921	1154	1388	1858	2327	2794	3256	3711

Calculated by Birnie's formula,

The notation is same as used above for Clavarino's formula.

Tables 11 and 12.—An exhaustive experimental research made by Prof. Reid T. Stewart on the collapsing pressure of lapwelded steel tubes (Trans. American Society Mechanical Engineers, Volume 27, page 730-822) resulted in the production of new formulas for the collapsing strength of tubes which give results for comparatively long lengths that differ greatly from those given in the older formulas. The principal conclusions to be drawn from Prof. Reid T. Stewart's researches may be briefly stated as follows:

1. The length of tube between transverse joints, stiffening rings, or end connections tending to hold it to a circular form has no practical effect upon the collapsing pressure of a commercial lapwelded tube so long as the length is not less than about six diameters of the tube.

2. The formulas as based upon researches for tubes 20 ft. in length between transverse joints or end connections tending to hold them to a circular form, which of course apply in practice without substantial error to any length greater than six diameters, for the collapsing pressures of National Tube Company's lapwelded Bessemer steel tubes, are as follows:

$$p=86,670\ \frac{t}{D}-1,386 \quad \text{.....................(B)}$$

$$p=50,210,000\left(\frac{t}{D}\right) \quad \text{.....................(G)}$$

Where p = collapsing pressure in pounds per square inch.
D = outside diameter of tube in inches.
t = thickness of wall in inches.

Formula (B) is for pressures greater than 581 pounds per square inch, or for values of t/D greater than 0.023, while formula (G) is for values less than these.

These formulas apply to steel having the following average physical properties: Tensile strength, 58,000 pounds per square inch; yield point, 37,000 pounds per square inch; elongation in eight inches, 22 per cent.; and reduction of area, 57 per cent. They have been tested for commercial lapwelded steel tubing in sizes from 3 to 12 inches outside diameter, for all the usual commercial thicknesses, but are believed to be applicable to a much greater range in size. Formula (B) gives results that are in substantial agreement with Professor Carman's experiments * on 1½ in. and 3½ in. cold drawn seamless steel boiler tubes.

Collapsing Pressure,* Lbs. Per Sq. Inch, For Lengths Greater than Six Diameters of Tube For Shelby Standard Cold Drawn Mechanical Tubing

TABLE 11 — Reid T. Stewart and R. L. W., 1907. — Chkd. by W. F. F

Outside Diam. Inches	THICKNESS IN GAGE AND FRACTIONS OF AN INCH: 22 BWG	20 BWG	18 BWG	1/16	3/32	1/8	5/32	3/16	7/32	1/4	5/16	3/8	1/2	5/8	3/4	7/8	1
½	3468	4681	7108	9448	14865	20282											
⅝	2497	3468	5409	7281	11615	15948											
¾	1850	2659	4276	5837	9448	13059	16670	20282									
⅞	1387	2081	3468	4805	7900	10995	14091	17186	20282								
1	1041	1647	2861	4031	6739	9448	12156	14865	17573	20282							
1⅛	771	1310	2389	3429	5837	8244	10652	13069	15467	17874							
1¼	564	1041	2011	2948	5114	7281	9448	11615	13781	15948	20282	24615					
1⅜	.....	820	1703	2554	4523	6493	8463	10433	12402	14372	18312	22251					
1½	.....	636	1445	2225	4031	5837	7642	9448	11253	13059	16670	20282	27504				
1¾	.....	.....	.....	1709	3257	4805	6352	7900	9448	10995	14091	17186	23377				
2	.....	.....	.....	1322	2677	4031	5385	6739	8094	9448	12156	14865	20282	25698			
2¼	.....	.....	.....	1022	2225	3429	4633	5837	7040	8244	10652	13059	17874	22689			
2½	.....	.....	.....	781	1864	2948	4031	5114	6198	7281	9448	11615	15948	20282			
2¾	.....	.....	.....	584	1569	2554	3538	4523	5508	6493	8463	10433	14372	18312			
3	.....	.....	.....	.....	1322	2225	3128	4031	4934	5837	7642	9448	13059	16670	20282	23893	27504
3¼	.....	.....	.....	.....	1114	1947	2781	3614	4448	5281	6948	8614	11948	15281	18615	21948	25282
3½	.....	.....	.....	.....	936	1709	2483	3257	4031	4805	6352	7900	10995	14091	17186	20282	23377
3¾	.....	.....	.....	.....	.....	1503	2225	2948	3670	4392	5837	7281	10170	13059	15948	18837	21726
4	....	.....	.....	.....	.....	1322	2000	2677	3354	4031	5385	6739	9448	12156	14865	17573	20282
4¼	.....	.....	.....	.....	.....	.....	1800	2438	3075	3712	4987	6261	8810	11359	13909	16458	19007
4½	.....	.....	.....	.....	.....	.....	1623	2225	2827	3429	4633	5837	8244	10652	13059	15467	17874
4¾	.....	.....	.....	.....	.....	.....	1465	2035	2605	3176	4316	5456	7737	10018	12299	14580	16860
5	.....	.....	.....	.....	.....	.....	1322	1864	2406	2948	4031	5114	7281	9448	11615	13781	15948
5½	.....	.....	.....	.....	.....	.....	1076	1569	2061	2554	3538	4523	6493	8463	10433	12402	14372

*Calculated by Stewart's formulas B and G.

Safe External Fluid Pressure,* Lbs. Per Sq. In., for Safety Factor of Five For Shelby Standard Cold Drawn Mechanical Tubing

TABLE 12 — Reid T. Stewart and R. L. W., 1907. — Chkd. by W. F. F.

Outside Diam. Inches	THICKNESS IN GAGE AND FRACTIONS OF AN INCH: 22 BWG	20 BWG	18 BWG	1/16	3/32	1/8	5/32	3/16	7/32	1/4	5/16	3/8	1/2	5/8	3/4	7/8	1
½	694	936	1422	1890	2973	4056											
⅝	499	694	1082	1456	2323	3190											
¾	370	532	855	1167	1890	2612	3334	4056									
⅞	277	416	694	961	1580	2199	2818	3437	4056								
1	208	329	572	806	1348	1890	2431	2973	3515	4056							
1⅛	154	262	478	686	1167	1649	2130	2612	3093	3575							
1¼	113	208	402	590	1023	1456	1890	2323	2756	3190	4056	4923					
1⅜	.....	164	341	511	905	1299	1693	2087	2480	2874	3662	4450					
1½	.....	127	289	445	806	1167	1528	1890	2251	2612	3334	4056	5501				
1¾	.....	.....	.....	342	651	961	1270	1580	1890	2199	2818	3437	4675				
2	.....	.....	.....	264	535	806	1077	1348	1619	1890	2431	2973	4056	5140			
2¼	.....	.....	.....	204	445	686	927	1167	1408	1649	2130	2612	3576	4538			
2½	.....	.....	.....	156	373	590	806	1023	1240	1456	1890	2323	3190	4056			
2¾	.....	.....	.....	117	314	511	708	905	1102	1299	1693	2087	2874	3662			
3	.....	.....	.....	.....	264	445	626	806	987	1167	1528	1890	2612	3334	4056	4779	5501
3¼	.....	.....	.....	.....	223	389	556	723	890	1056	1390	1723	2390	3056	3723	4390	5056
3½	.....	.....	.....	.....	187	342	497	651	806	961	1270	1580	2199	2818	3437	4056	4675
3¾	.....	.....	.....	.....	.....	301	445	590	734	878	1167	1456	2034	2612	3190	3767	4345
4	.....	.....	.....	.....	.....	264	400	535	671	806	1077	1348	1890	2431	2973	3515	4056
4¼	.....	.....	.....	.....	.....	.....	360	488	615	742	997	1252	1762	2272	2782	3292	3801
4½	.....	.....	.....	.....	.....	.....	325	445	565	686	927	1167	1649	2130	2612	3093	3575
4¾	.....	.....	.....	.....	.....	.....	293	407	521	635	863	1091	1547	2004	2460	2916	3372
5	.....	.....	.....	.....	.....	.....	264	373	481	590	806	1023	1456	1890	2323	2756	3190
5½	.....	.....	.....	.....	.....	.....	215	314	412	511	708	905	1299	1693	2087	2480	2874

*Calculated by Stewart's formulas.

3. Both the modulus of elasticity, E, and the elastic limit of the material appear to have a joint influence in determining the strength of a tube to resist external fluid pressure, the former being paramount for tubes having very thin walls of say t/D less than 0.023, the latter being paramount for ratios of t/D greater than say 0.06, while they both exert an influence in varying degrees for intermediate ratios. That is to say, for tubes made of materials having physical properties other than those stated above, the collapsing pressures, other things being equal, will vary approximately for thin walls as the moduli of elasticity and for thick walls as the elastic limits of the materials. The apparent circumferential fiber stresses under which the different tubes failed, varied from about 7,000 pounds for the relatively thinnest to 35,000 pounds per square inch for the relatively thickest walls.

Table 11 was calculated by means of formulas (B) and (G), pages 793 and 795, Volume 27, Trans. American Society Mechanical Engineers, and is applicable to lengths greater than six diameters of tube between transverse joints or end connections tending to hold it to circular form. No experiments have yet been made to determine the collapsing strength of Shelby mechanical tubing. There appears, however, to be no reason why these formulas should not apply with sufficient accuracy for practical purposes to regular stock material. Accordingly Table 11 has been calculated by means of these formulas for Shelby standard cold drawn mechanical tubing in regular stock material and medium anneal. This table will probably give values for regular stock material that are somewhat too high for "Soft Anneal" and somewhat too low for "Finish Anneal," the difference being relatively greater for thick than for thin walls.

When applying this table of collapsing pressures to practice it must be remembered that a suitable safety factor should be applied. Ordinarily a safety factor of five is sufficient when the stresses due to actions other than a constant fluid pressure are more or less trivial. In case there is repeated fluctuations of the fluid pressure, vibration, shock, internal strain due to unequal heating, etc., then a larger safety factor of from six to twelve or more should be used depending upon the severity of these actions.

Table 12 is calculated directly from the preceding table by dividing each entry by five.

* Bulletin No. 5, page 6, of University of Illinois Engineering Experiment Station.

RAILROAD REGULATION. — No one conversant with the facts will deny that there have been mistakes and wrong-doing on the part of the railroads and other large corporations, and the corporations, as well as all good citizens, are glad that checks to stop them have been devised. I do not question the right, the wisdom, or the necessity for the supervision and regulation of railroads by the nation or state that creates them. Under our form of government the people rule, and the terms "rule" and "regulate" are synonymous.—*W. C. Brown.*

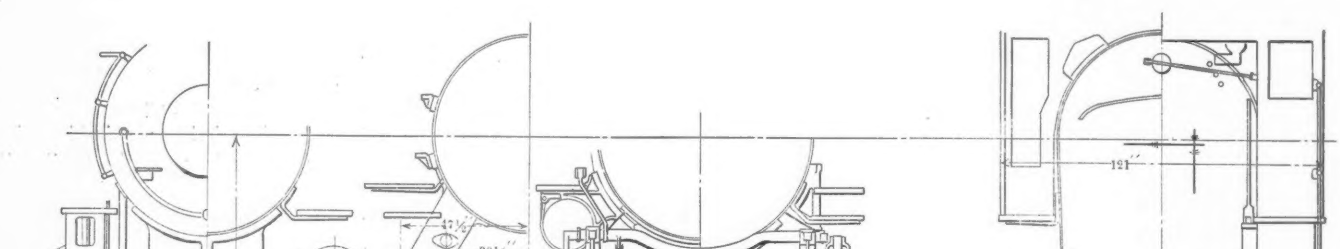
PACIFIC TYPE LOCOMOTIVE WITH COMBUSTION CHAMBER—NORTHERN PACIFIC RAILWAY.

PACIFIC AND ATLANTIC TYPE LOCOMOTIVES.

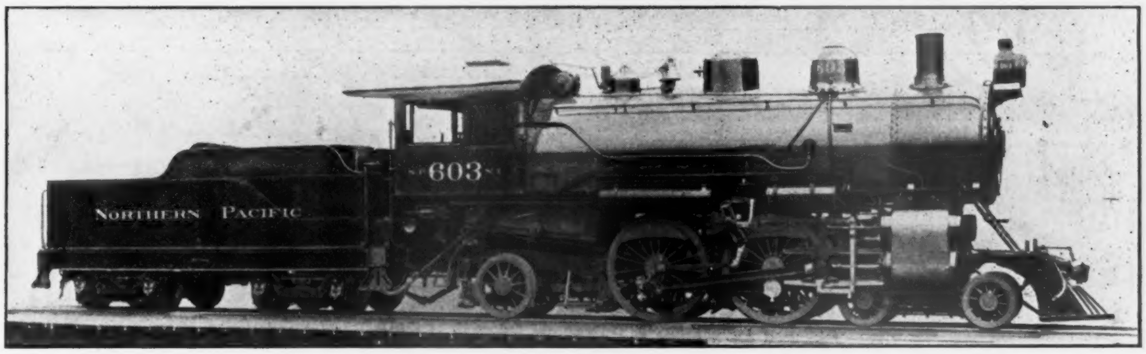
NORTHERN PACIFIC RAILWAY.

Pacific type locomotives were introduced on the Northern Pacific Railway in 1902, by A. E. Mitchell, superintendent of motive power. At that time the Schenectady works of the American Locomotive Company built 20 locomotives having 22 x 26 in. cylinders, 69 in. drivers and 200 lbs. boiler pressure for this company. Seven of these had piston valves and thirteen, slide valves. Five of them were equipped with the Davis counter balance. This design was illustrated in the AMERICAN ENGINEER, February, 1903, page 63. This class was followed in 1904 and 1905, at which time Mr. Van Alstyne was superintendent of motive power, by 18 locomotives having the same size cylinders, drivers and steam pressure, but a larger boiler, the weight being increased from 195,000 to 219,000 lbs. These locomotives were illustrated on page 8 of the January, 1905, issue of this journal. In the latter part of 1906, 20 more Pacific type locomotives were built by the American Locomotive Company, which were practically identical with the previous order, with the exception of the boiler, which in this case included a combustion chamber, 3 ft. in length, and a reduction in the number and length of flues. One of these locomotives was equipped with a Schenectady superheater. These locomotives were fully illustrated in this journal October, 1906, page 392. About two months later the same company turned out two balanced compound Pacific type locomotives for the Northern Pacific, which at that time were the heaviest locomotives ever built, weighing 240,000 lbs. These engines also had combustion chambers and included the Walschaert valve gear. They were illustrated on page 411 of the November, 1906, issue of this journal.

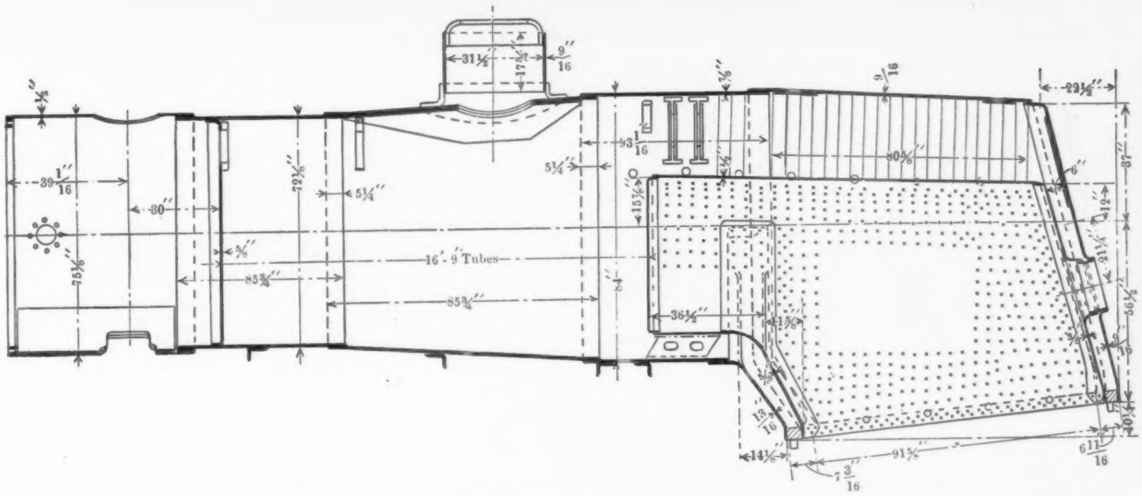
At this time this company then had in operation Pacific type locomotives of practically identical power as follows: Simple engines without combustion chamber or superheater; simple engines with combustion chamber and without superheater; simple



ELEVATION AND SECTIONS—PACIFIC TYPE LOCOMOTIVE—NORTHERN PACIFIC RAILWAY.



ATLANTIC TYPE LOCOMOTIVE WITH SUPERHEATER—NORTHERN PACIFIC RAILWAY.



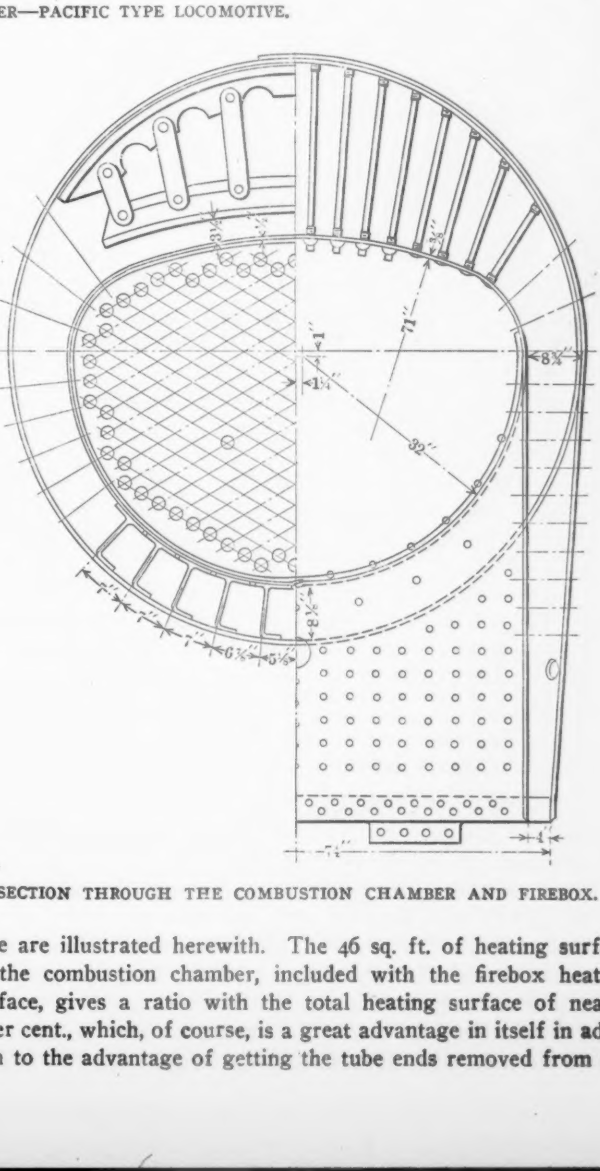
BOILER WITH COMBUSTION CHAMBER—PACIFIC TYPE LOCOMOTIVE.

engines with combustion chamber and superheater and balanced compound engines with combustion chamber and without superheater.

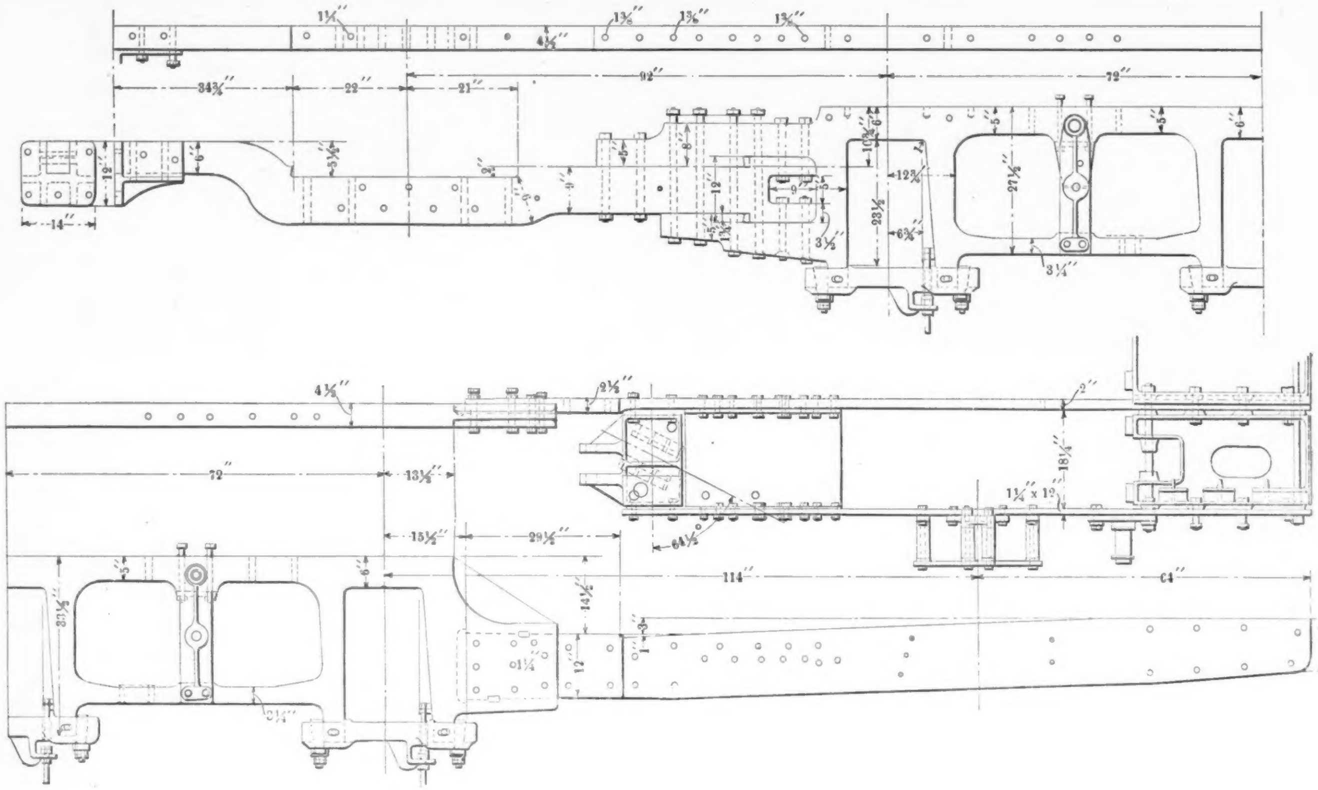
During this period of development of course changes in details were made as found desirable on each new order. Experience was obtained with both piston and slide valves, with Stephenson and Walschaert valve gear, in addition to the boiler and cylinder arrangements, and in August, 1907, 10 engines were ordered from the American Locomotive Company which had simple cylinders 22 x 26 in., 69 in. wheels and a boiler with combustion chamber, but no superheater, being practical duplicates of those previously built by the same company in 1906. They had Stephenson valve gear.

The latest step in this development is found in the design which is illustrated herewith, ten of which have recently been completed by the Baldwin Locomotive Works. These locomotives have combustion chambers, simple 22 x 26 in. cylinders, 12 in. piston valves and Walschaert valve gear. It has been found in practice that balanced compound cylinders, while fully successful, were not adapted to the service for which these locomotives are to be used, and for that reason simple cylinders have been specified. The combustion chamber has proved to be a complete success and the slight trouble which had been found with leaky seams has been eliminated in this last design by welding the connections between the combustion chamber ring, the crown sheet and the throat sheet. The experience with the superheater has evidently not been conclusive, as accompanying this order of Pacific type locomotives there are three of the Atlantic type, two of which are equipped with the Schmidt superheater. The design of the 4-6-2 engines is almost identical with the last order of simple locomotives of this type mentioned above, the principal difference being the use of the Walschaert valve gear in place of the Stephenson.

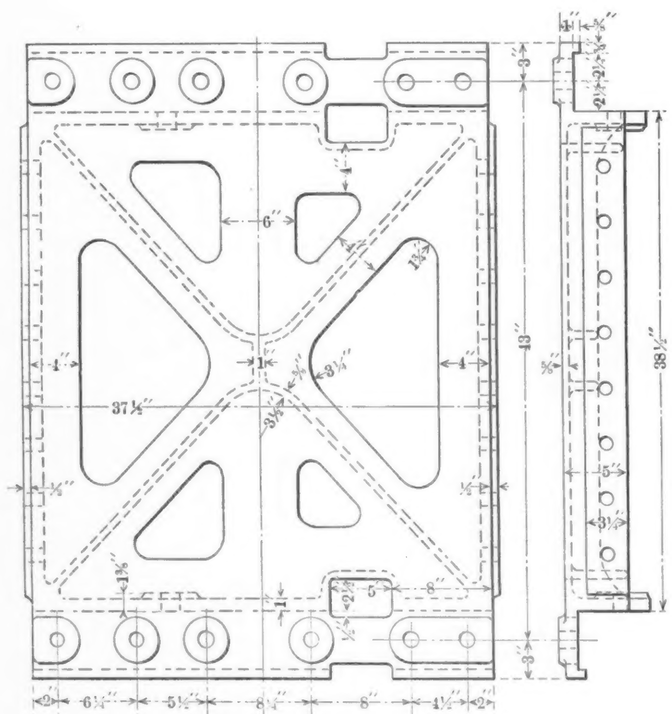
In view of the fact that this design can be considered as having been most thoroughly and carefully tried out in service covering several years, the details of the boiler and frames of the Pacific type are illustrated herewith. The 46 sq. ft. of heating surface in the combustion chamber, included with the firebox heating surface, gives a ratio with the total heating surface of nearly 8 per cent., which, of course, is a great advantage in itself in addition to the advantage of getting the tube ends removed from the



SECTION THROUGH THE COMBUSTION CHAMBER AND FIREBOX.



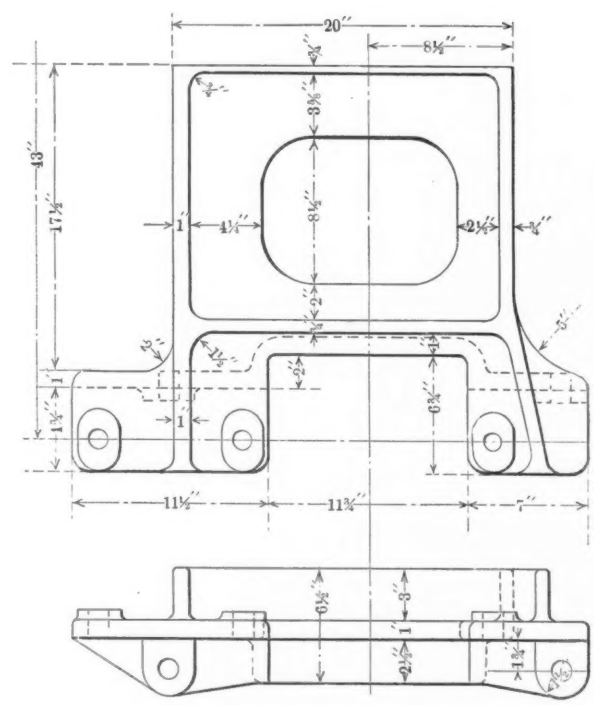
FRAMES—PACIFIC TYPE LOCOMOTIVE, NORTHERN PACIFIC RAILWAY.



FRAME BRACE BETWEEN SECOND AND THIRD PEDESTALS.

direct action of the flames. A brick arch supported on a single water tube is used. Careful attention has been given to providing ample space around the combustion chamber for circulation, particularly at the bottom. The grate area of 43.5 sq. ft. bears a ratio of 1 to 66 to the total heating surface.

The boiler of the Atlantic type locomotives is practically the same as that of the Pacific with the exception that the combustion chamber has not been used and the tubes are shorter. It carries but 185 lbs. pressure. The two boilers fitted with the superheater have 196 2-in. tubes in place of 306, and use 22-5⅜ in. tubes for

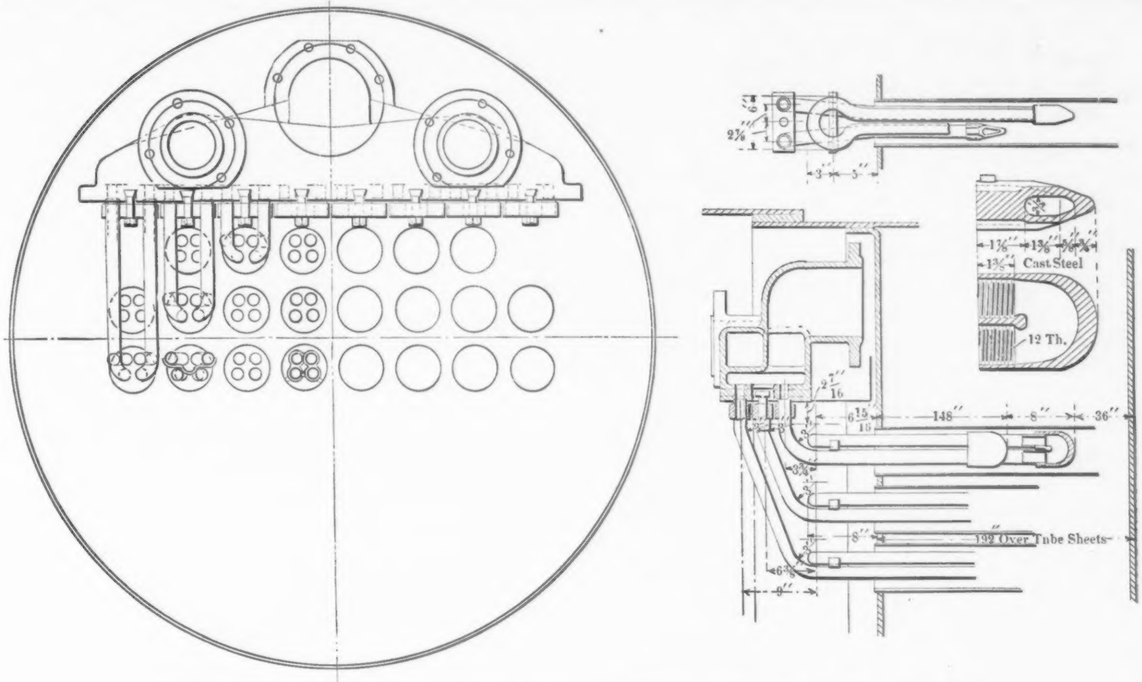


FRAME BRACE OVER FRONT PEDESTAL.

the superheater elements. The heating surface of the superheater itself is 430 sq. ft. The ratios given for the Atlantic type engine are for the one without a superheater.

The frame construction is interesting and excellent and is identical with that used on the last 4-6-2 type order. The front frames are separate from the main frames and the connection between the two has been very carefully studied and is a proved success. The cast steel frame braces, which are shown in detail, are located over the front pedestal and between the second and third pedestals. They are broad and substantial and located where the greatest strains are known to occur. A cast steel bearer for the link and reverse shaft located between the first and second pedestals also acts as a frame brace.

The Atlantic type locomotives use the same cylinder and cylin-



SCHMIDT SUPERHEATER ON ATLANTIC TYPE LOCOMOTIVE, NORTHERN PACIFIC RAILWAY.

der heads as the Pacific, the difference in the diameter of piston being obtained by the introduction of a bushing. The valve motion details on the two designs are interchangeable wherever possible. The trailing truck on the Atlantic type has inside journals, while the Pacific type has outside journals. The method of frame bracing is also somewhat different in the two designs.

The general dimensions, weights and ratios are given in the following table:

GENERAL DATA.		
Type	4—6—2	4—4—2
Gauge	4 ft. 8½ in.	
Service	Passenger	
Fuel	Bit. Coal.	
Tractive effort	31,000 lbs.	24,760 lbs.
Weight in working order	233,250 lbs.	197.050 lbs.
Weight on drivers	144,350 lbs.	100,800 lbs.
Weight on leading truck	47,000 lbs.	51,950 lbs.
Weight on trailing truck	41,900 lbs.	44,300 lbs.
Weight of engine and tender in working order	375,000 ibs.	320,000 lbs.
Wheel base, driving	12 ft.	6 ft. 10 in.
Wheel base, total	32 ft. 6 in.	27 ft. 10 in.
Wheel base, engine and tender	61 ft. 11 in.	57 ft. 3 in.
RATIOS.		
Weight on drivers ÷ tractive effort	4.66	4.05
Total weight ÷ tractive effort	7.50	7.95
Tractive effort × diam. drivers ÷ heating surface	743.00	665.00
Total heating surface ÷ grate area	66.10	62.20
Firebox heating surface ÷ total heating surface, %	7.70	6.38
Weight on drivers ÷ total heating surface	50.00	37.00
Total weight ÷ total heating surface	81.00	72.40
Volume both cylinders, cu. ft	11.40	10.40
Total heating surface ÷ vol. cylinders	252.00	261.00
Grate area ÷ vol. cylinders	3.82	4.19
CYLINDERS.		
Kind	Simple	
Diameter and stroke	22 x 26 in.	21 x 26 in.
VALVES.		
Kind	Piston	Piston
Diameter	12 in.	12 in.
Valve gear	Walschaert	
WHEELS.		
Driving, diameter over tires	69 in.	73 in.
Driving, thickness of tires	3½ in.	3½ in.
Driving journals, main, diameter and length	9½ x 12 in.	9½ x 12 in.
Driving journals, others, diameter and length	9 x 12 in.	9½ x 12 in.
Engine truck wheels, diameter	33½ in.	33½ in.
Engine truck journals	6 x 11 in	6½ x 12 in.
Trailing truck wheels, diameter	45 in.	45 in.
Trailing truck journals	8 x 14 in.	8 x 14 in.
BOILER.		
Style	Conical	Straight
Working pressure	200 lbs.	185 lbs.
Outside diameter of first ring	72⅛ in.	
Firebox, length and width	96 x 65¼ in.	
Firebox plates, thickness	⅜ & ⅝ in.	
Firebox, water space	F.—4½, S. & B.—4 in.	
Tubes, number and outside diameter	306—2	
Tubes, length	16 ft. 9 in.	16 ft.
Heating surface, tubes	2,665 sq. ft.	2,543 sq. ft.
Heating surface, firebox	174 sq. ft.	173 sq. ft.
Heating surface, combustion chamber	46 sq. ft.	....
Heating surface, total	2,885 sq. ft.	2,718 sq, ft.
Grate area	43.5 sq. ft.	
TENDER.		
Frame	13 in. chan.	
Wheels, diameter	33½ in.	
Journals, diameter and length	5½ x 10 in.	
Water capacity	7,000 gals.	6,000 gals.
Coal capacity	12 tons	9 tons.

Superheater locomotives have:—

Small tubes	196—2 in.
Large tubes	22—5⅜ in.
Heating surface, firebox	173 sq. ft.
Heating surface, tubes	2,112 sq. ft.
Heating surface, total	2,287 sq. ft.
Superheater heating surface	480 sq. ft.

PENNSYLVANIA RAILROAD SYSTEM.

The annual, "Record of Transportation Lines," recently issued by the Pennsylvania Railroad, shows that on December 31, 1908, this system had 11,236 miles of line and 23,977.4 miles of track. Of this 14,089.76 miles are east of Pittsburgh and Erie and 9,887.65 are west of these points. During the year the total trackage increased 405 miles. The system lines now have 3,326 miles of double track, 784 of triple track and 564 miles of four-track line.

During 1908 the Pennsylvania Railroad carried 142,676,779 passengers, an average of over three trips for every inhabitant of the States through which its lines run. Likewise during the year the company handled 334,429,541 tons of freight, an average of nearly eight tons to every person living in the States it serves. The estimated population of the States through which the lines of the Pennsylvania Railroad run was on January 1, 1909, 44,936,522, or almost exactly half of the estimated population of the whole United States.

During the year the system carried on an average of 316,098 passengers over every mile of its line and an average of 2,621,631 tons of freight over every mile of the line.

SHORT BELT CENTERS.—In driving the new and extra powerful tools for using high-speed steel, much attention has been paid to trains of gearing and endless chains for getting sufficient torque, the poor old-fashioned belt being neglected as being too weak and of no account. The trouble with the old-time belt drive was that the belts were run much too slow, hence did not have the capacity to transmit much power. I have found, however, that the cheapest and most practical method to drive a shaft from a motor is with a short belt running at high speed and endless. A small belt running at 3,000 to 4,000 feet a minute will transmit an enormous amount of power and can be kept so loose as not to be strained up to its working limit, thus being very durable. Because it runs loosely the shafts are not pulled together, so that there is very little journal friction and wear. There need not be any fear of its being too short between pulley centers if it is strong, thin, endless and runs at high speed.—*Oberlin Smith before the A. S. M. E.*